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J. McKEEN CATTELL AND F. R. MOULTON
WARE CATTELL, Associate Editor

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THE GENESIS OF A CURRICULUM IN BIOLOGICAL ENGINEERING

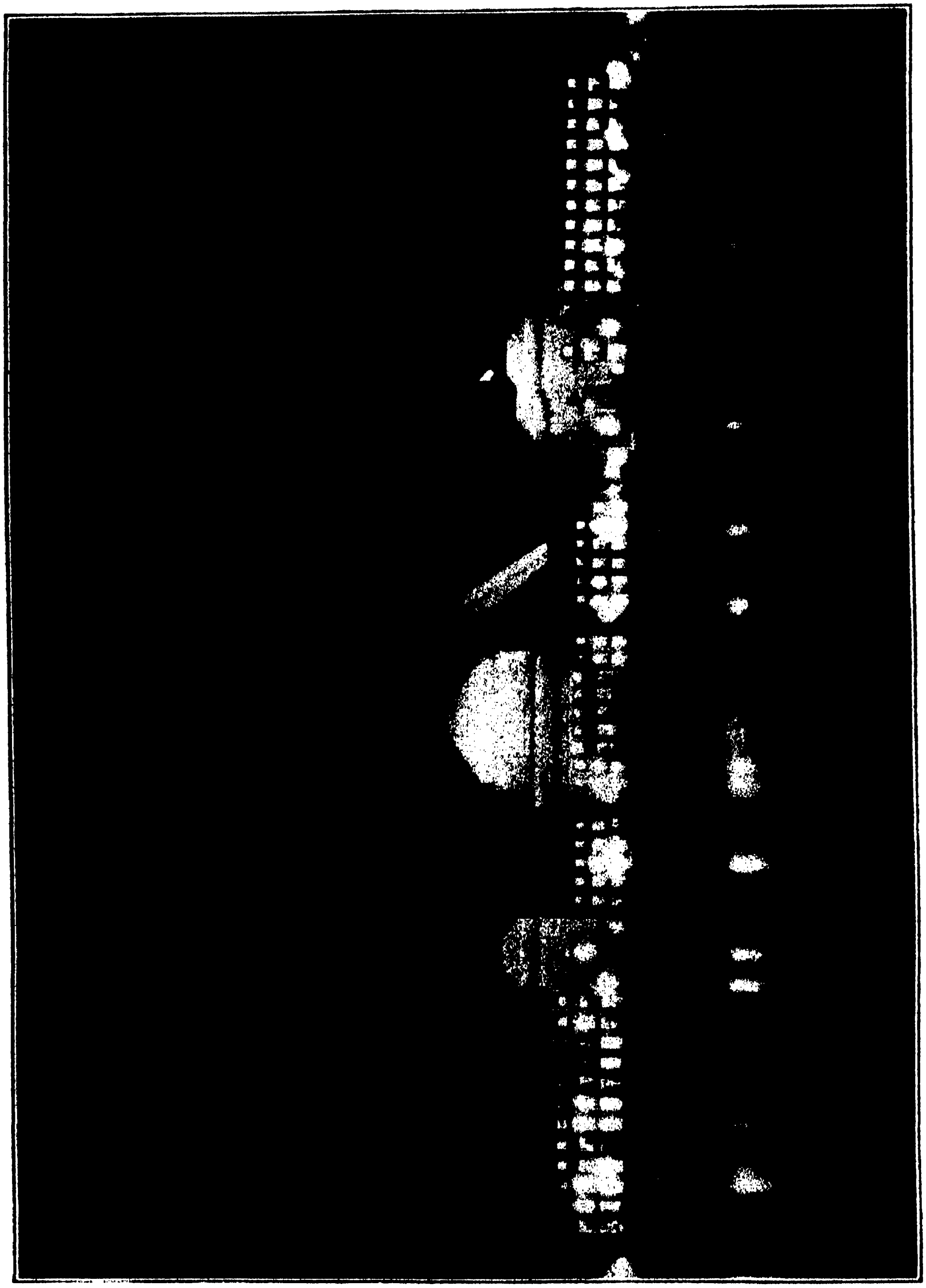
By President KARL T. COMPTON and Dr. JOHN W. M. BUNKER
THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

ONE hundred years ago there were but two types of engineers, "military" engineers concerned with the operations of warfare and "civil" engineers whose activities were directed toward problems of civil life. Each utilized many identical techniques in mensuration over the surface of the earth but with different objectives; each was concerned with the building of roads and bridges for which the same scientific data and similar mathematical computations were employed. Neither exercised a monopoly on any particular applications of science; their objectives were different.

For a time, all engineering in civil life was civil engineering, but as some of these engineers became engaged in delving into the earth to secure mineral resources, adaptations of usual procedures in the matter of structures, methods of tunneling, bracing and the like led to the designation of these specialists as "mining" engineers. On the other hand, those engineers who specialized in the harnessing of mechanisms to manufacture, employing the principles of mechanics, came to be known as "mechanical" engineers, the first college curriculum in this field being established at Rensselaer Polytechnic Institute in 1862. Shortly thereafter the increasing applications of electricity in its manifold possibilities to aid the mechanical engineer called for specialization of training and practice in that branch of physics comprised in the field of electricity, as a result of which technical courses in electrical engineering were developed at M.I.T. in 1882.

Meanwhile, the sciences of chemistry and physics and, to a less spectacular degree, the science of biology had been accelerated in their development, and their so-called boundaries expanded until they overlapped. The service of chemistry to biology was obvious, and biochemistry existed at the interphase between the two long before formal recognition of this state came with its definite designation by name.

Chemistry was impressed also into the service of industry, and the utilization of chemistry with a judicious employment of physical and mechanical engineering principles in chemical manufacture was explored systematically and with encouraging results. Alert to the possibilities with which this merger of chemistry and engineering was potent, in 1888 President Francis J. Walker at the Massachusetts Institute of Technology included in its curriculum the first program of training in chemical engineering. Fifteen years later Professor William Walker, teacher of industrial chemistry at M.I.T., conceived the pedagogical plan of instruction in unit processes, such as distillation, dehydration, heat transfer and other processes which are common to many industries, replacing the plan of detailed description of particular processes of manufacture. The art of train-



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ing chemical engineers therefore emerged by metamorphosis, as it were, after an incubation period of fifteen years and, having spread its wings, took off in strong flight, which is still successfully maintained.

The applications of these basic principles in the engineering manner was the logical sequence to such preliminary pedagogical training. By the application of this view-point of unit processes to industry itself, order arose from chaos; the problems of chemical industry became reduced to common terms; technical advances in one branch of industry were transferable to other branches. In the short space of thirty years chemical engineering has become one of the most vigorous and useful of all the applied sciences.

Biology is the name given to one subdivision of natural science and relates particularly to life and the products of living things. Originally a matter of observation, description and classification, "natural history" designated the scope of biology. Following the period of description and classification of forms, there developed a period of inquiry into the nature of these forms, the changes which they were observed to undergo and the accumulation of data concerning the analysis of life processes. Thus there was developed a body of facts within the broad field of biology which came to be designated as physiology. Great advances in physiology followed the demonstration that the functions of life are largely manifestations of chemical reactions. Utilization by the physiologist of the expanding knowledge in the field of science designated as that of organic chemistry brought about a corresponding expansion in our knowledge of the phenomena of life, and the accumulation of chemical data related to physiological happenings constitutes the basis of the subscience physiological chemistry or biochemistry.

A noteworthy advance in the study of all branches of chemistry has arisen from the demonstration of the essential unity of its subject-matters with those of pure physics. Chemist and physicist alike investigate the structure of matter and its behavior, and chemical secrets are being resolved by experimental and theoretical physics.

Living and non-living matter have in common a structure of matter, molecules, atoms and electrons, subject to the same laws of energetics. The very term "physician" and "physicist" are derived from the same root, φύσις, meaning nature as distinguished from the spiritual, mental or moral world. In the early days of science there was no sharp distinction between animate and inanimate phenomena. Pioneers in scientific observation concerned themselves with medicine, physics and alchemy.

Like pendulums swinging in opposite directions, so the history of science shows often a tendency toward expansion by specialization followed by convergence. As knowledge of natural sciences grew, specialization was a necessary phase of development in its major fields. Medicine and engineering emerged as combinations of art and applied science, medicine being based upon biology and engineering upon physics. Both medicine and engineering have taken unto themselves that which they may require from the richness of chemical knowledge, and each has become more efficient by such a merger.

Convergence of specialized fields comes about when some fundamental discovery discloses the underlying unity, the basic processes, of two branches of science which have developed apparently divergently on less fundamental and apparently unrelated bases. A generation ago it was easy to distinguish between a chemist and a physicist; the latter dealt with matter in bulk, the former with changes in molecular constitution. There still exists what might be called a plumbing type of physics and the culinary type of chem-

istry, but in their interpretative and many of their operational aspects the two sciences are now completely merged, to their very great mutual advantage. Every competent chemist is to some degree a physical chemist, and no observer of physical interactions can escape observation of chemical changes. It was only lack of information which compelled men to proceed along different lines based on imperfect conceptions of what appeared in our ignorance to be different sets of fundamental laws.

We now have learned a little more of truth, and perceive that the physical laws which formulate the relations of matter and energy in the lifeless world also apply to these relations in the world of the living. Biological science is one category of facts, relations and laws concerning matter and energy, just as chemistry and physics are other categories of the same broad classification. No boundaries exist to delimit sharply the fields of natural science; each merges into the other as the grass on the suburban lawn merges with that of the neighbor's yard. Names which are attached to centers of interest in each field are for convenience in description and reference and do not represent individual factual entities.

It is well recognized that man's achievement, all through the ages, has depended to a large degree upon the tools at his disposal. Already the techniques of experimental physics and chemistry have been applied in the study of biology with success, and the greater precision of measurement and of description of biological phenomena made possible thereby have changed the character of modern biology from descriptive to analytical. It is especially true in biology, due to the unpredictable idiosyncrasies of living specimens brought about by individual variations of environment or of heredity, that only by repetition can tests of theory establish truth. True repetition can be effected only when reproducible precision of essential measurement characterizes the tests. Chemical and physical measurements in biological investigation have supplied the precision necessary for successful experimentation.

As a result of the era of specialization in all fields of science, the biologist trained in the past finds himself to-day incompletely informed of the finest techniques of his brother specialists in physics, chemistry and mathematics. To acquire a comprehensive background of biological information, he has not had time to specialize in other sciences; the magnitude of the variety of experimental procedures in the various fields is beyond the comprehension and attainment of one mortal, it would require a superman.

Cooperation of specialists would seem to supply one answer to the dilemma which each faces. Cooperation means working together, it requires the ability to give and take mutually, and this give and take must not generate into "You give and I take." Cooperation requires adjustment of ideas when ideas are based upon imperfect premises. Cooperators must be able to reason logically and to yield to logic. They must be able to argue without acrimony, to convince or be convinced. If the answers were known in advance, there would be no need for search or research. Since the answers are not known, they must be sought by the formulation of hypotheses and the experimental testing thereof. This requires information and reasoning together with experimental skills.

Where there is a little knowledge but not enough, two heads should be better than one in gaining more. But man is a stubborn animal; and scientists are prone to be opinionated. The line between confidence and conceit is vague; the one quality is necessary for achievement, but the other is irritating to one's fellow man. Hence there are problems of human behavior and human reaction to be met with in cooperation. Without patience, differences of opinion are rarely resolvable. The very imperfection of words to convey the meaning intended by the user requires meticulous definition in discus-

sion of scientific matters—and in other misunderstandings as well. To be specific, the biologist, chemist and physicist are conventionally trained in different terminologies and approach their problems with somewhat different attitudes. Cooperation does not come about like the amalgamation of mercury and other metal. It is something to be cultivated and nourished like a delicate organism until it acquires a sturdy habit of existence.

In 1931 one of us set about to study the technique of cooperation. Trained in biology, he formed a liaison with a fellow staff member of the research laboratories of organic chemistry, and later this was extended to calling in a physicist and various other experts. The results of some of these cooperative endeavors will be cited later in this chapter. The result of the first five years of this pleasant but at times turbulent experience proved several interesting things. One was that the art of cooperation can be learned and can be fostered. Another was the widespread interest held among scientists in matters which taxonomically belong in the field of another (perhaps analogous to the human interest we have in the business of other persons). A third was the demonstration that pooling of ideas and techniques is profitable in results.

Meanwhile, numerous sporadic inquiries from students in biology, physics and chemistry indicated some real interest in the question of preparation for professional work in biophysics or biochemistry. There is evidently an appreciation, by the thoughtful undergraduate, of the opportunities for useful work in the borderline fields between these sciences. The obvious answer to these inquiries seemed to be analogous to the reply of the modern dentist to the inquiry as to what one can do to insure teeth against decay, "See to it that your grandmother had a diet adequate in the basic nutritional elements, phosphorus, calcium and appropriate vitamins." The student who had specialized in physics without attention to biology had no means of acquiring a background of biological appreciation of natural phenomena without beginning all over again in biology; likewise, with the biologist who had spent his time on the various phases of his subject, exposing himself only to the conventionally required minimum of mathematics, chemistry and physics. As the result of experience and observation of the disadvantages of this procedure, and after consideration of the practical and pedagogical elements involved, we became convinced that the training of the biochemist or biophysicist could advantageously start simultaneously in biology and the sister sciences.

It is with satisfaction that one notes an agreement with this principle as indicated by the utterance of Dr. Detlev W. Bronk, director of the Eldridge Reeves Johnson Foundation, who, in addressing the Symposium on Biophysics sponsored in 1937 by the American Institute of Physics at Philadelphia, referred to the growth of biological research with the aid of the methods of physics and pointed out that too few students learn physics and biology together from the ground up.

Upon the above premises and with the objective of designing a curriculum in biophysics, two colleagues were called into conference, Professors Stockbarger and Warren. An analysis was made of the concepts, tools, techniques and opportunities involved in the proposed program, and it was agreed for a working premise that work in the proposed field will be largely concerned with experimental biology, and that the means of experimentation will include the application and the techniques of physical and chemical measurements of energy and reactions.

Among the types of energy likely to be usable there seemed to be the following: electromagnetic vibrations—infrared, visible, ultra-violet, radio frequencies, x-rays; radioactivity; electricity, electrons, neutrons, etc.; supersonics and

ultrasonics; heat; chemical energy; magnetism.

Among the ways in which these and other types of energy are likely to be involved are the following: stimulation of protoplasms; chemical changes induced in organic materials once living or the products of the once living; effects on enzyme action; therapeutic effects in disease; abiotic effects on deleterious cells or parasites; effects on hormones or vitamins; electrokinetics of membranes; permeability of surface films and membranes; electrophoresis of cells; mutations; photochemical reactions; spectroscopy of biologic materials; explanations of metabolism in general.

There may be required the construction and operation of devices for securing objective measurements of changes induced as above, and also the measurement and recording of the following: temperature, pressure, humidity, air motion, gaseous relations; motion and time; amplification of feeble energies without distortion, by mechanical or photronic electrical devices; radiation measurements, x-ray dosages, other radiations, such as radioactivity, cosmic ray counting, mitogenetic radiation; hydrogen ion concentration; oxidation-reduction potentials; vapor pressures; heat flow, insulation thermodynamics; surface tension; conductance and impedance in protoplasms; diffusion and osmotic effects across membranes; molecular weights and isoelectric points; colloidal phenomena; agglutination and antibody reactions; electrical potentials; Donnan equilibria; Helmholtz double layer phenomena; axone potentials and action currents; reflex time and tropisms.

Among the technical skills which will be useful in constructing experimental and recording apparatus the following are suggested: design and construction of amplifier circuits, transformers, meters; machine tool work, welding, hard and soft soldering; wood-working, glass-working, glass metal seals; vacuum pumps, maintenance and measurements of high vacuums, manometry, use of McLeod gauge and other devices for measuring gas and/or vapor pressures; production and maintenance of uniform or varying temperatures, including cryoscopic work; thermionic, vacuum tube, thyratron circuits; scientific photography and photometry; optical measurements; radiation measurements; spectroscopy, absorption and emission spectra, extinction coefficients; spectroscopic analysis of biological materials; supersonic devices; radiation sources (electromagnetic, monochromatic, etc.); optical filters; use of the research microscope, transmitted and oblique illumination; the ultra microscope, dark field, quartz lens microscope, lithium-fluoride microscope; monochromators, quartz, lithium-fluoride; gaseous conditions for same; preparation and handling of pure gases.

Among the fields of usefulness in which a biophysicist may find employment is research in pure or applied biology, as in: medical schools; hospitals; medical and biological institutes; universities; institutes of biophysics; food companies, packers, canners, bakers, shippers, etc.; manufacturers of pharmaceuticals, chemicals or drugs; industrial hygiene; governmental laboratories, agriculture, food, health and standards; unforeseen outlets.

Fortunately for our purpose, an examination of the various curricula in the eighteen courses of study already available in our institution disclosed a wealth of material dealing with the basic sciences. A mosaic of selected courses of instruction in biology, chemistry, electrical engineering, organic, physical and colloidal chemistry, mathematics, theoretical and experimental physics was fitted together without serious conflicts of time schedules which gave a first approximation to the desired new curriculum.

It was judged that an educational program in four years could not be suffi-

VII-A. BIOPHYSICS AND BIOLOGICAL ENGINEERING

		First Year			
	First term			**Second term**	
Course No.	**Subject**	**Units**	**Course No.**	**Subject**	**Units**
5.01	Chemistry, General	7–4	5.02	Chemistry, General	7–4
8.01	Physics	6–5	8.02	Physics	6–5
D11	Engineering Drawing	6–0	D12	Descriptive Geometry	6–0
E11	English Composition	3–5	E12	English Composition	3–5
M11	Calculus	3–6	M12	Calculus	3–6
MS11	Military Science	3–0	MS12	Military Science	3–0
PT1	Physical Training	1–0	PT2	Physical Training	1–0
		Second Year			
5.11	Qual. Analysis	7–2	5.12	Quant. Analysis	7–2
7.01	Biology, Gen.	5–2	7.14	Comp. Anatomy	8–2
8.03	Physics	5–5	8.04	Physics	6–4
E21	Lit. & History	3–5	E22	Lit. & History	3–5
M21	Calculus	3–6	M22	Diff. Equations	3–6
MS21	Mil. Science	3–0	MS22	Mil. Science	3–0
	Gen. Study	2–2			
		28–22			
		Summer			
5.41	Organic Chem. I	4–3			
5.428	Organic Chem. Lab. I	10–0			
		Third Year			
5.61	Phys. Chem. I		5.62	Phys. Chem. II	4–4
5.611	Phys. Chem. Lab.	4–0	5.621	Phys. Chem. Lab. II	4–0
7.10T	Invert. Zool.	8–4	6.00	Elec. Eng. Prin.	4–4
7.301	Bacteriology	6–4	6.75	Elec. Eng. Lab.	2–2
Ec11	Political Economy	3–3	7.20	Physiology	6–4
	Language	3–5	Ec12	Political Econ.	3–3
		28–20		Language	3–5
					26–22
		Fourth Year			
6.01T	Elec. Eng. Prin.	5–7	7.84	Biophysics	6–3
6.761	Elec. Eng. Lab.	2–3	8.311	Atomic Struct.	3–5
7.80	Biochemistry	8–5	8.312	Atomic St. Lab.	3–2
8.09	Physical Meas.	3–2		General Study	2–2
8.161	Optics	3–6		Electives	20
8.162	Optical Meas.	3–2			
					49
		24–25			
		Fifth Year			
7.321	Adv. Bact.	3–4	7.82	Adv. Biochem.	6–3
7.81	Zymology	6–3	7.92	Biol. Eng. II	4–2
7.91	Biol. Eng. I	6–3	10.662	Colloid Chem.	2–4
10.661	Int. Colloid Chem.	2–4		Elective	9
	Elective	9		Thesis	20
	Thesis	10			
					50
		50			

ciently broad to give a fundamental grasp of the essential elements of biology, chemistry and physics here involved and at the same time go sufficiently into these fields to give power of using the concepts and techniques listed above. The proposed educational program must therefore be based upon a combination of undergraduate and graduate work. By extending the program through five years, the necessary minimum of training can be offered, including type applications of fundamentals to concrete biological problems.

This five-year program of study went into effect in September, 1936. Upon its satisfactory completion a student may be recommended for the degree of master of science in biological engineering and bachelor of science in biophysics (as of the preceding year).

The curriculum which is now in effect is presented herewith. The "unit" of class work or preparation consists of one hour per week for fifteen weeks; for instance, the symbols "7–4" mean seven hours of recitation, lecture or laboratory and the estimated preparation time of four hours per week.

The choice of the name "biological engineering" is the result of much thought and consultation, and it has been

adopted in spite of its temporary abandonment when we were first searching for the precisely appropriate title to describe our objective. The name biophysics is not sufficiently definitive, and biochemistry is insufficiently inclusive. Such varied etymological combinations as biurgy, biodynamics and biotechnology were examined and discarded. The designation accepted was urged by Dr. Vannevar Bush as being appropriate because our objective so aptly conforms to the well-known definition of engineering as "the art of organizing and directing men and of controlling forces and materials of nature for the benefit of the human race." Within this conception lies ample scope for every activity from instrumentation to theory, including biophysics and biochemistry (which, in fact, contribute greatly to the meaning of physiology) so long as the major objective is the marshalling of all available resources to aid biology for the benefit of humanity. With clear vision, Dr. Bush stated, "I know you don't like the name now, but it will grow on you as you think it over." He was right.

A few concrete illustrations of the results which have been derived from the pooling of scientific resources to a common objective will be cited.

Seven years ago Dr. Nicholas A. Milas, of the Research Laboratory of Organic Chemistry at M.I.T., being interested in the broad subject of oxidations, discovered and reported the production of a peroxide of secondary butyl alcohol prepared by irradiating this reagent with ultraviolet light. The scientific interest of this finding was in itself sufficient justification for the planning and effort expended in its demonstration. In the course of conversations with a colleague in the department of biology, speculation arose as to whether or not this new compound, containing a source of active oxygen, might not have the property of killing bacteria. A test with the appropriate methods for determining germicidal property substantiated the hope. Clearly this chemical novelty had potential value of useful application in an unforeseen direction. Another colleague, impressed with the favorable surface tension property of the butanol solution and irritated by the discomfort of a foot infection which had remained with him from his days in college athletics, expressed curiosity as to whether this reagent could possibly be effective in combatting epidermophytosis of the type commonly called "athlete's foot." Cautiously applying the butanol peroxide to one infected foot, leaving the other untreated as a control, no one was more surprised than he at the speedy relief from discomfort which followed and at the definite healing process which ensued. This observation naturally led to systematic testing of the fungicidal properties of the new reagent by approved cup-plate tests with serum agar, and its fungicidal value as well as its penetrating properties was found to be superior to the usual medicinal agents available for therapeutic use in this ailment.

The stability of the peroxide solution under ordinary storage conditions being inadequate for practical medical use, a further series of investigations by Dr. Milas resulted in a method of chemical synthesis of an allied but different compound, namely, the hydroperoxide of tertiary butanol which, having been put through the same paces with encouraging results, has been tried clinically in hundreds of cases with such success that the material has been put into manufacture and is now available to the medical profession. As a further instance of how unpredictable results may come from the testing of hypotheses, it is pertinent to state that this medicinal preparation, already proved useful for fungus infections of the skin, has found new and promising uses in oral hygiene and in dental surgery.

A second instance of the profitable combination of science and engineering is the development of an instrument, the electrocardiotachometer, whose applica-

tion has been in an unexpected direction. Based upon representations from European laboratories that in certain vitaminic deficiencies in the albino rat, the pulse rate of the animal is a useful diagnostic symptom, Professor R. S. Harris decided to investigate the pulse rate of some of his own white rats in the department of biology. There are at least two reasons why such a procedure is difficult. First, the albino rat, tame though it be, does not take kindly to having its wrist held; second, if by palpitation one endeavors to count the heart rate of the albino rat he finds himself in difficulty because that rate is normally between 450 and 500 beats per minute, which is too fast to count.

The dilemma was laid before Professor J. W. Horton, at that time attached to the electrical engineering department, and he called upon his recent experience in utilizing vacuum tube circuits for the purpose of counting cosmic ray impacts. By certain modifications, he devised equipment for picking up the minute voltages incident to each heart-beat through electrodes applied externally to the body of the rat, filtering out the bothersome muscle voltages, amplifying those desired, and fitting the impulses to an appropriate meter which, when calibrated, records instantaneously the desired rate of heart-beat. By the time that the kinks had been ironed out of this instrument its preliminary use had shown so great a variation in the pulse rate of a single animal during its waking and sleeping periods that the significance of the pulse rate as a diagnostic symptom was shown to be without value for the purpose intended. However, the application of this identical electrocardiotachometer to a patient under anesthesia during a surgical operation in a local hospital enabled the operating surgeon as well as the anesthetist to read the pulse rate of the patient at a glance and released one hand of the anesthetist, previously required for taking the pulse, for other useful purposes, and this application to human surgery has aroused much favorable and enthusiastic interest.

A third example of a contribution of physics to medicine arose independently of the development of cooperative effort in biophysics or biological engineering, but is a dramatic illustration of how science can be brought to the service of humanity. We refer to the work of Dr. Robley D. Evans, of our department of physics, who became interested in the unhappy condition which befell certain young women a few years ago while engaged in painting luminous dials on watches with radium paint who, by the careless practice of moistening their paint brushes on their lips to make a fine point, inoculated themselves unwittingly with radio-active material which is, of course, one of the most potent poisons known to man. In the hope of alleviating this condition of radium poisoning in the human being Dr. Evans secured the help of medical colleagues and with the active collaboration of Dr. Joseph C. Aub, of the Huntington Memorial Hospital in Boston, an expert on calcium metabolism, there was evolved the method of therapeutic treatment which has given the greatest relief to victims of radium poisoning. The medical part of this procedure involves the mobilization of calcium from bones into the blood stream and its elimination from the body. Radium, like calcium, when introduced anywhere into the body, migrates in part to the bones, where it is stored and where it may cause malignancy in the bones, resulting subsequently in death of the patient if even so small an amount as one millionth of a gram of radium is retained. But radium leaves the bones along with calcium when bone calcium is moved into blood and out of the body. Dr. Evans devised a most delicate Geiger counter and the ingenious method of using it to determine at any time with great precision not only the total amount of radium in the body, but also its anatomical position. This gave

the physician a tool for gauging the success of his treatment. When the patient has been depleted of calcium as far as seems safe, the treatment is then reversed and a diet rich in calcium is supplied and new calcium free from radium tends to reform a healthy bone structure. Dr. Evans was given the Theobald Smith award in 1937 for his part in this very valuable work.

A fourth illustration of a useful result from collaboration between departments is the development of a new method for the production of vitamin D from appropriate sterol precursors by application of the energy of particles of high velocity excited in the electromagnetic field of a high frequency radio oscillator. This method was conceived by a chemist who was acquainted with the electrodeless discharge. Drawn into the development were also a biologist interested in the vitaminic potency of the product, an electrical engineer as designer of the electrical equipment and several physicists acquainted with the properties of electrically excited particles. This process is being used in industrial production.

The problems of importance to the welfare of mankind which should be susceptible of solution by the biological engineer are numerous and of great economic significance. He will be a pioneer on a new frontier with vast possibilities for useful endeavor spread before his ken. An explorer in ill-mapped territory, he may indeed lose his way at times, but so did Christopher Columbus, who (as pointed out by Clarence Francis in an address before the Industrial Research Conference at Ohio State University on November 4, 1938), through an error in navigation did not find India, whose spices he sought. "It was a golden error! For what Columbus did was to come upon a new world, change the existing trade routes, awaken mankind's curiosity, spur explorations, stimulate scientific research, improve the world's food supplies and point the way to health and long life by way of the balanced diet." Columbus as a navigator may have been no more adept than many of his peers, but he surpassed them all in confidence and perseverance, and he was alert to capitalize an unexpected observation, qualities necessary for the successful prosecution of useful scientific research.

The yearly destruction of food and of food crops by animal and plant parasites runs into millions of dollars. More efficient fungicides and insecticides are required, and rational methods for their efficient use are needed. Campaigns for the eradication of such parasites as those which cause the Dutch elm tree disease and the chestnut blight must be organized and carried through for public welfare with the methodical planning of the engineer.

Termite destruction of wooden structures is a menace against which more efficient methods of combat must be devised with due regard to the breeding and nutritional habits of the invader.

In our harbors the damage by shipworms and other biologic infestations is of far greater magnitude than landsmen realize. Within the last two years in Boston Harbor alone the cost of replacing piling, wharves and bulkheads ruined by marine borers is of the order of five million dollars. New York harbor with its piers and docks has been free from significant trouble of this sort. Test boards maintained in the North River and examined monthly by Wm. F. Clapp, lecturer in marine economics at M.I.T., have shown the first shipworm, a 35 millimeter teredo, on November 29, 1938. This has followed the diversion of substantially 20 per cent. of the pollution from that body of water through the meritorious efforts of the Sanitary Commission, which proposes to divert an additional 30 per cent. in 1939. Shipworms in their invasive stage can not withstand sewage pollution; as it is removed, they may be expected to invade, and once they

are present one breeding season will result in their entry into unprotected wooden structures below salt water level. Once they have gained entry through minute holes which they bore, they tunnel as they grow until a porous shell of insufficient structural strength results and the piling fails to maintain its load. Means for combatting shipworms are known, but better, cheaper, more efficient methods must be devised and applied on a large scale to prevent tremendous economic loss from this menace.

Continued developments of physics and chemistry in the service of public health and of therapeutic medicine are to be expected, and these aspects of applied science must be not only developed but made applicable on a large scale for the good of all. Biology has already shown the way with aid of chemistry to combat malaria, diphtheria and many more of the communicable diseases; no one yet knows how to control infantile paralysis or the common cold. Pandemic diseases of the venereal group are still a scourge to mankind. We know relatively little of the transmission of virus diseases and not very much of the nature of viruses.

Recent biological byproducts of the new discoveries in atomic physics undoubtedly open up an enormous vista of opportunities for investigating the nature of biological processes in conditions of disease and health. A majority of the kinds of chemical atoms can now be produced in the radioactive state and used as "tracer elements" of prodigious sensitivity in the study of physiological processes. In some cases they can be used as therapeutic agents. Isotopes, also, can be used as biological or chemical tracers. Here are new tools, made available to the biologist by his colleagues in physics and chemistry, which may well rival the microscope and the x-ray in their ability to open up hitherto unexplored territory.

The human mechanism and the myriad forms of life which share its environment can be most intelligently controlled for the maintenance of health and the avoidance of ills only after man learns how these living mechanisms operate. The more complete his knowledge of the fundamental energy transformations and other chemical reactions of life in general and of human life in particular, the better can he expect to live and the more efficiently can he hope to promote the welfare of all.

Training in biological engineering is offered not as a mere intellectual invention but in recognition of an existing situation and a present need. The curriculum described above is designed to meet that need, and it was derived from a study of practical problems susceptible to cooperation between scientists each a master in his own field and sympathetically interested in the other's. Graduates with this new type of training should be equipped with technical skills and broad appreciation of fundamentals to a degree which, combined with moderation, zeal, persistence and ingenuity, should lead to success in research and in its applications.

A fresh field of useful endeavor lies before the young man of ability, imagination and courage. There are few if any ruts in this field into which the biological engineer may stumble. He must set his own course, for beaten paths are not there. No frontier of applied science has ever been presented to the scientific explorer more rich in possibilities of improving human welfare; no scientific explorer has been equipped with such diverse resources and instrumentation for useful research as are at the command of the biological engineer. Here is opportunity; how will it be met?

ALBERT ABRAHAM MICHELSON

ALBERT ABRAHAM MICHELSON

THE FIRST AMERICAN NOBEL LAUREATE

By Dr. ROBERT A. MILLIKAN

DIRECTOR OF THE NORMAN BRIDGE LABORATORY OF PHYSICS, CALIFORNIA INSTITUTE OF TECHNOLOGY

It will probably be generally agreed that the three American physicists whose work has been most epoch-making and whose names are most certain to be frequently heard wherever and whenever in future years the story of physics is told are Benjamin Franklin, Josiah Willard Gibbs and Albert A. Michelson. And yet the three have almost no characteristics in common. Franklin lives as a physicist because, dilettante though he is sometimes called, mere qualitative interpreter though he actually was, yet it was he who with altogether amazing insight laid the real foundations on which the whole superstructure of electrical theory and interpretation has been erected. Gibbs lives because, profound scholar, matchless analyst that he was, he did for statistical mechanics and for thermodynamics what Laplace did for celestial mechanics and Maxwell did for electrodynamics, namely, made his field a well-nigh finished theoretical structure. Michelson, pure experimentalist, designer of instruments, refiner of techniques, lives because in the field of optics he drove the refinement of measurement to its limits and by so doing showed a skeptical world what far-reaching consequences can follow from that sort of a process and what new vistas of knowledge can be opened up by it. It was a lesson the world had to learn. The results of learning it are reflected to-day in the extraordinary recent discoveries in the field of electronics, of radioactivity, of vitamins, of hormones, of nuclear structure, etc. All these fields owe a large debt to Michelson, the pioneer in the art of measurement of extraordinarily minute quantities and effects.

I. Michelson, the Man

Of all those who take their place in the company of the immortals the world is intensely interested in knowing not merely their accomplishments, but how they got started in the line they followed and what manner of men they were. Not very much of this can be learned from Michelson's writings, much less than from those of most equally famous men, and for that reason this memoir must take on, to an unusual degree, the character of a personal narrative.

The total volume of Michelson's published work is very small. In an active life as a physicist, extending from the age of twenty-five to that of seventy-nine, he wrote two small books that are found in all libraries. The first is entitled "Light Waves and Their Uses" (University of Chicago Press, 1903). It represents his Lowell Lectures delivered in 1899. The second is "Studies in Optics" (University of Chicago Press, 1927), and consists of a condensed summary of his major researches. These books contain some revealing and quotable passages which are used by Hale[1] and Lemon[2] in interesting and informing articles on Michelson.

His bibliography of scientific papers contains but seventy-eight titles all told, and many of these are abstracts and most of them are quite short articles. Not a few of them are reprintings of the same article in different journals and different languages. One's knowledge of Michelson must be gained, then, more

[1] *Astronomical Society of the Pacific*, 43: 175, 1931.

[2] *The American Physics Teacher*, 4: 1, 1936.

from what he did than from what he said. Also, one must call upon the testimony of those who, like the present writer, lived and worked side by side with him for a quarter century and more. That testimony will, I think, be unanimous in the judgment that his most outstanding characteristic was his extraordinary honesty, his abhorrence alike of careless, inexact, ambiguous statement, as well as of all deception and misstatement. His was a remarkably clean-cut mind, which left little room for adjustment and compromise.

Every one knows that he was a remarkably accurate and dependable scientific observer, but not every one knows how well he succeeded in doing what every scientist should do but which many do not succeed in doing, namely, in carrying over that exceptional dependability into all his relations with his fellows. At one time, when he had become the subject of some criticism, one of the critics came to me and to another of Michelson's associates, and asked whether these criticisms were well founded. Our joint reply was, "Don't ask us; ask him. He'll tell you." The critic took the advice and returned with the statement, "He certainly told me!" His whole effort seemed to be to see and to state things just as they were. The writer played tennis with him for twenty-five years, and watched him call balls. In doing so he was always just and correct, but never generous either to himself or to his opponent. He did not even fool himself, as most of us do, in the analysis of his own motives. Even when those motives were incorrect from the standpoint of his associates, he stated them frankly and with amazing honesty, in one remarkable instance apologizing for his attitude and expressing regret that he was "built that way." Almost any one else would have rationalized his conduct into a virtue, and lied both to himself and his critics, as we are now seeing done so continuously and so deplorably in our political life.

I am quite certain that the last thing Professor Michelson would desire would be to have this memoir made merely a eulogy. I am therefore endeavoring to give first as correct a picture as I can of the man as I knew him through more than twenty-five years of intimate association.

If his most outstanding characteristic was his honesty, his second most notable characteristic was the singleness, simplicity and clarity of his objective—an objective from which he let nothing divert him, however great the pressure. He was an intense individualist, he knew what he wanted to do, he had confidence in his ability to do it, and he refused to let anything divert him from it, no matter what other interests had to be sacrificed or who stood in the way. The result was that he made no pretense of keeping widely informed outside his own field. Indeed, he was always depreciating his own knowledge even of the field of physics, despite the fact that he was quite fond of telling the incident of how he once told G. Stanley Hall that if he wanted to keep a first-rate physicist like himself at Clark University he would have to treat him like a first-rate physicist.

There is no doubt, too, that in fields other than physics his reactions were sometimes hasty and occasionally purely emotional. This was well illustrated at the time of the blowing up of the *Maine*. President Harper had asked the historian Van Holst and the ex-navy man and scientist Michelson to address the assembly of the students at the University of Chicago upon the situation that had been created by that incident. Van Holst counselled caution, delay and painstaking investigation before any action was taken or even thought of. Michelson was for declaring war at once and immediately taking drastic steps.

But the best illustration of his singleness of purpose is furnished by the early history of the Ryerson Laboratory.

From a scientific point of view this consisted very largely of the history of Michelson's individual contributions. Some of the personal sides of that history are worth telling here for the light they throw on Michelson, the man. I first met him at the exercises connected with the dedication of the laboratory at the spring convocation of the year 1894. He had been the commencement speaker, and in his address had emphasized the significance of refinement of measurement for the progress of science—a significance which subsequent years have shown to be vastly greater than even he foresaw, inspired prophet though he was. Incidentally, in that address he used another's words, I think Kelvin's, as to the unlikelihood of future discoveries coming from other work than that involving the sixth place of decimals. He afterwards upbraided himself unmercifully to me for ever having done so.

At the dinner which he gave in the evening of that day to some fifty visiting physicists he was rallied for introducing personal charm as an attribute of the coming six-decimal-place physicist, for with his jet black hair, his attractive hazel eyes, his faultless attire and his elegant and dignified bearing, he made a striking figure, though his height was not over five feet seven or eight. The next day I attended his first lecture to the group of some six or seven graduate students, who were there for the work of the summer quarter at the University of Chicago. He was himself the graduate department, giving the only graduate course. The impression that was made upon me by that course and by his presentation of the "visibility curves" which had recently been obtained—curves which enabled one by the aid of skilful observing and more skilful analysis to read for the first time the fine structure of spectral lines far beyond the power of any instrument to reveal it directly to the eye—was memorable. This course, along with about two conversations which I had with him when he came to my room to see how I was getting along with my measurements on the polarization of the light emitted by incandescent surfaces, impressed me with the fact that I was in the presence of one who had a far deeper understanding of optics than any one I had thus far met. Elegance of observational technique, elegance of analysis, elegance of presentation—these were, I think, the impressions made on all of us younger men who had a chance to see Michelson's experimental work and hear him present it. He always lectured twice a week and quizzed once on the ground covered in the two preceding lectures, and he could cover more ground in an hour than any lecturer I ever heard. The two texts which he relied upon mostly for the material of his lectures, when he was not presenting his own work, were Mascart and Joubert's "Electricity and Magnetism" and Rayleigh's "Sound." The material covered in his lectures embraced the whole fields of electricity, sound and optics. He did nothing with thermodynamics, to which he had a certain aversion, probably because of its extreme generality and lack of concreteness—I think he greatly underestimated its value and its accomplishment—and while he was sympathetic with the kinetic theory and molecular physics, he incorporated little of this field into his courses. Also, the newer physics—radioactivity, electronics and quantum theory—were largely outside the field of his interest, though of the Zeeman effect he made a careful study, both experimental and theoretical, and when x-rays were discovered he stepped aside from his routine, as nearly every one else did, to try to contribute something to the elucidation of the source and nature of the new phenomenon.

It was probably fortunate for me in my very limited relations with him as pupil

(summer of 1894, only) and my long-continued relations with him as a subordinate member of his staff, that I had my own problems in which he only assisted me incidentally, and that I was never either his immediate assistant or his collaborator; for at least in those earlier years Professor Michelson's attempts in Chicago at collaborative work, either with staff members or with graduate students, did not in general turn out very well either from his own point of view or from that of the collaborator. In the case of both of the two staff members with whom in the nineties he tried to do some work in common, difficulties arose, and when one of them left about 1900 he assured me that my "turn would come next." And yet during the next twenty-one years during which I was with him I could not have asked for more considerate and courteous treatment than I uniformly received from Professor Michelson. It is true that on two occasions I thought he was wrong and told him so, but his explanations were so completely straightforward and disarming that I could only laugh and tell him that he was the most honest man I had ever met.

His relations with graduate students during the ten years from 1894 to 1904 tell much the same story. He assigned but few thesis subjects and no small proportion of these turned out none too happily. I think it was in 1905 that he called me to his office and said, "If you can find some other way to handle it I don't want to bother any more with this thesis business. What these graduate students always do with my problems, if I turn them over to them, is either to spoil the problem for me because they haven't the capacity to handle it as I want it handled, and yet they make it impossible for me to discharge them and do the problem myself; or else, on the other hand, they get good results and at once begin to think the problem is theirs instead of mine, when in fact the knowing of what kind of a problem it is worth while to attack is in general more important than the mere carrying out of the necessary steps. So I prefer not to bother with graduate students' theses any longer. I will hire my own assistant by the month, a man who will not think I owe him anything further than to see that he gets his monthly check. You take care of the graduate students in any way you see fit and I'll be your debtor forever." From that time on Professor Michelson assigned very few, if any, thesis problems. And this decision was the correct one for him to make, for he gauged his own qualities and capacities correctly. He knew what he was best fitted to do, and he did not let anything or anybody deter him from that course. He took no part in general university administrative or instructional problems outside the department of physics. I never saw him in a faculty meeting despite the fact that, in the early days of the University of Chicago, faculty meetings were very important affairs where university policies were very thoroughly threshed out.

His regular departmental routine was as follows: He met his class of graduate students regularly three times a week for two lectures and one quiz. All graduate students took his courses when they were ready for them. His lectures were carefully prepared. They were very condensed, with most of the details left for the students to work out. They were considered hard courses. He worked every day with his personal assistant, and often with the mechanician, in his research laboratory, and about four o'clock he regularly went over to the Quadrangle Club to play tennis or billiards, at both of which he was quite proficient. His evenings he spent at home; for his life with his second wife, Edna Stanton (married in 1900), and their three daughters was an altogether happy one, although his earlier marriage had not in the end turned out successfully.

The foregoing characteristics explain,

perhaps, the fact that during his earlier years Michelson acquired the reputation of being somewhat unapproachable, difficult, dictatorial, even inconsiderate. If he possessed these qualities in the earlier part of his life he certainly lost them in the later part, for the mellowing effect of his later years was particularly noteworthy. It was commented upon by all his intimates, as well as by his students. It is shown, too, by the fact that his first wife, from whom he was divorced in 1897 and who was later Mrs. Margaret Hemingway Shepherd, and by whom he had three children, one daughter and two sons (one of whom is at present an ethnologist in the Bureau of American Ethnology of the Smithsonian Institution)[8] wrote me in 1932 that before his death he sent his lawyer to her to ask her forgiveness for any suffering he might have caused her.

II. Michelson's Parentage, Childhood, and Youth

Albert Abraham Michelson was born at Strelno, then in Germany, a small town near the frontier of Poland, on December 19, 1852. His mother, Rosalie Przlubska, was the daughter of a well-known physician, and was left motherless in early youth. In her various duties for the household she met, fell in love with and married the proprietor of a dry goods shop, a man of forty years, Samuel Michelson. She was then but eighteen years of age. Before 1855 two children had been born, a boy and a girl. Because of the troublous times existing in that year in Poland, they decided to come to America, where Samuel Michelson had a sister living in California. They took passage via Panama to San Francisco, and then moved on to the lovely little mountain town in Calaveras County called Murphy's Camp, described by Bret Harte in one of his stories, where Albert's early childhood was spent.

As the young Michelson grew older he was sent to San Francisco to school, where "he developed few companionships," but where he lived for several years with the family of the principal of the high school, who later paid him three dollars a month—his first earnings—to keep the physical instruments in order. When Albert was sixteen he went back to the home of his father, who by that time had moved his dry goods business to Virginia City, Nevada, famous because of the history of the Comstock lode and more famous because of the immortality which Mark Twain gave it. The elder Michelson wished his son Albert to enter the Navy, so when, the next year, there was a vacancy in Nevada's quota, Albert took the examination for congressional appointment to Annapolis. He tied with another boy, who through influence got the appointment while Michelson was made alternate, but also given, by the local Congressman, a personal letter to President Grant which it was hoped might enable him to get one of the ten special Presidential appointments at large to the academy. He obtained his interview with the President, who, however, informed him that he had already exhausted his ten appointments at large. Nevertheless, one of the President's naval aids told young Michelson to go over to Annapolis, since there was still a chance of a vacancy through the failure of one of the new appointees who had not yet passed his examination. After three days of waiting at Annapolis this hope failed, and Michelson was just starting back for Washington to try again with the President when the Commandant sent a messenger after him and informed him that the President had given him "an appointment at large." Since this was the eleventh such appointment Michelson always maintained that his career was started by an illegal act.

III. Michelson and the Velocity of Light

In November of that same year, 1877, while studying, for the purposes of a

[8] Very recently deceased.

lecture, the three purely terrestrial determinations of the velocity of light that had thus far been made—one by Fizeau in 1849, one by Cornu in 1872, both by Fizeau's toothed-wheel method, and one in 1862 by Foucault—a slight but, for accuracy, a very vital modification of the Foucault method suggested itself to Michelson, which, to quote his own words, "dispenses with Foucault's concave mirror and permits the use of any distance."

Foucault, and, following him, Newcomb, who with the aid of a relatively large congressional appropriation had for some time prior to any work by Michelson been working at a determination of the velocity of light by a modification of Foucault's method, had placed the rotating mirror between the lens and the mirror used to return the beam back to the rotating mirror. In order to get enough light this required the use of a relatively large rotating mirror, and in Foucault's case the distance between the two mirrors was only twenty meters. It is to be remembered, however, that Foucault's apparatus was designed to permit the insertion between the mirrors of a tube filled with water, for his primary purpose was to determine whether the speed of light was greater in air or in water, for this was the crucial problem of his day, and this problem he successfully solved. It is true, however, that with his arrangement it was impossible to get enough light to enable the use of a large distance between the two mirrors. Also, when in 1872 Cornu went at a precise, absolute determination he studied carefully and elaborately Foucault's rotating mirror method, and discarded it because he could not extend the intermirror distance to more than thirty meters. Michelson, though only an inexperienced youth of twenty-four, with that quick insight into the vital elements of an experimental problem which was characteristic of all his design work, saw what other scientists of the highest repute who had studied the rotating mirror method had failed to see, namely, that by simply placing the point (or line) source at the principal focus of the lens so that the beam went out from the lens as a parallel bundle of rays which could be returned on itself as a parallel beam by a plane mirror *placed at any desired distance*, and then using a *small*, rotating mirror placed just in front of the point source, he could use any distance that he wished without any loss of light. This would make Foucault's rotating mirror method altogether comparable with Fizeau's rotating toothed-wheel method for an absolute measurement. Between November, 1877, and March, 1878, he built at an expense of ten dollars a rotating mirror, and using with it a lens which he found in the physics lecture equipment at Annapolis he obtained a displacement of 5 millimeters, while Foucault had had a displacement of .8 millimeters. Michelson wrote these results to the editor of the *American Journal of Science*. This letter takes up half a page of the May issue of 1878, and is Michelson's first publication. At the suggestion of his wife, her father in July, 1878, gave him $2,000 for improving the precision of the method, and he was presently using a distance of 700 meters, instead of 20, and getting 133 millimeters deflection. As a result of all his early determinations by this technique he obtained the value 299,895 kilometers per second, a value which he regarded as correct to one part in 10,000.

This problem, with which his career began, was also the one with which it closed. Four years before his death, at the age of seventy-five, he published in the *Astrophysical Journal*, 65: 1–14, 1927, the final mean of the results of his measurement made by sending a beam from Mt. Wilson to Mt. San Antonio, California, and back, 35 kilometers distant. The method now used, however, is essentially a combination of Fizeau's method and of Foucault's, since now Fizeau's rotating toothed-wheel is re-

placed by a rotating octagonal mirror, and the time of double transit of the light is the time it takes one face of the octagon to rotate into the position of the adjacent face. The advantage of this rotating mirror arrangement is that the angle of the octagon can be measured much more accurately than the mean distance between the teeth of the rotating wheel. He got from these measurements the value 299,796 kilometers per second.

Not content with this experiment because of the possible disturbance of the air-path between the two mountains, he spent the last four years of his life preparing for and redetermining near Santa Ana, California, this velocity by means of multiple reflections between the ends of an underground pipe 1,600 meters long, 30 centimeters in diameter, from which the air had been pumped out to such an extent as to make it possible to measure directly for the first time the velocity essentially in vacuo. The final mean result, published after his death, may be taken as 299,774, which is one part in 2,500 less than the best mean of his earlier measurements, another illustration of the fact that even the best of us tend to overestimate the precision of our work. The introduction to this last paper was written by Michelson but ten days before he lost consciousness. As he wrote it, it had the same title as the paper with which he began his career, "On a Method of Measuring the Velocity of Light."

Going back, now, to the beginning of his career: By the measurement made in 1879 at Annapolis, Michelson had sprung at the age of twenty-six, and while he was still "Ensign Michelson of the U. S. Navy," into international repute as a physicist. That he received immediate popular acknowledgment is shown by the following interesting quotation from a local Virginia City paper published on May 15, 1879, less than a year after his first published determination of the

Ensign A. A. Michelson, a son of S. Michelson, the dry goods merchant of this city, has aroused the attention of the scientific minds of the country by his remarkable discoveries in measuring the velocity of light. The *N. Y. Times* in an article says that "it would seem that the scientific world of America is destined to be adorned with a new and brilliant name." Ensign A. A. Michelson, a graduate of Annapolis, not yet 27 years old, is distinguishing himself by studies in the science of optics in measuring the velocity of light.

But the importance of Michelson's work on the velocity of light is not to be measured alone by the absolute determinations thus far considered. He began his work in the period in which physicists were trying to obtain crucial tests to distinguish definitely, if possible, between a wave theory and a corpuscular theory of light. Indeed, Foucault's method had been designed and used by him in 1862 primarily for the sake of finding by direct measurement whether the velocity in air was greater or less than the velocity in water, and he actually interposed a tube of water, closed at the ends by plane parallel glass plates, between his lens and his concave reflector and showed that the velocity is less in water than in air, as the wave theory demanded. In 1884, after Michelson had become (in 1883) professor of physics at Case School of Applied Science at Cleveland, he repeated this experiment of Foucault's and checked not only the latter's qualitative result, but he now made it definitely quantitative. He showed, also, that the ratio of the velocities in air and water is equal to the index of refraction, as demanded by the wave theory. He then performed the same experiment with carbon disulfide and here found the ratio of the velocities 1.75 instead of 1.64, as expected from the index of refraction. Confident, however, in the accuracy of his measurement, he published his results in spite of the apparent contradiction. Lord Rayleigh later removed the contradiction by showing that in a highly dispersive medium like carbon disulfide the

group velocity is less than that computed from the mean index of refraction, and that the theory was quantitatively in accord with Michelson's measurements. Michelson also tested directly the velocities of red and blue light and found the former 2 per cent. greater than the latter —a result of much importance at that time for the theory of dispersion.

IV. Michelson and the Interferometer

However important his work on the velocity of light may have been, the permanence of Michelson's place in physics undoubtedly rests in largest measure upon his invention of the Michelson interferometer and what he accomplished with it. Claude Bernard says that "a good technique sometimes renders more service to science than the elaboration of highly theoretical speculations," and George Hale has often remarked to me that "after all the progress of physics is written in the history of the development of new instrumental techniques." Be this as it may, the history of the interferometer shows how vitally theory and experiment cooperate in the progress of science.

Early in 1879 Michelson left the Naval Academy, where he had been instructor in physics and chemistry since December 15, 1875, and was then employed for a year at the office of the Nautical Almanac in Washington. He and his wife and their two young children then started for Europe, and he spent two years studying at Berlin, at Heidelberg and at the Collège de France. At Paris he acquired a good command of French and became well acquainted with the French physicists of that period, particularly Mascart and Cornu, the latter of whom had made by Fizeau's toothed-wheel method a very excellent determination of the velocity of light, the value of which then stood at 299,990, while Michelson's value was at that time 299,940. It is probable that it was his careful study here in Paris of Fizeau's work that got him started on his main lifework in interferometry. For it was as early as 1851 that Fizeau had made his remarkable experiment on the effect of moving water on the speed of light passing through it. The method consisted in bringing into interference two rays of light after their passage through parallel tubes in which water was driven with a high speed, in one tube in the direction of travel of the light and in the other tube against that direction. It was but a step from this Fizeau form of interferometer to the one used by Michelson in which the two components of the split beam of light are sent off in directions at right angles to each other and brought back by mirrors placed at right angles to each beam, to the original separating surface for the observation of the fringes. The complete control of the path of each beam, however, and the possibility of varying each path at will, or of introducing in either path materials of any sort whose optical properties it might be desired to study, gave it an extraordinary flexibility as a tool for making exceedingly refined measurements. It is not too much to say that Michelson spent a large part of his active life and did his most important work in devising new uses for this tool and carrying out researches of all sorts with its aid. In a sense, the tool had been here for decades before him, but why had not its possibilities been seen and utilized? Michelson once told me that when he first set up such a device in Paris and told Cornu how he got the fringes, Cornu was skeptical until he put a piece of cardboard in one of the right-angular paths and saw the fringes instantly disappear.

Michelson's first use of his interferometer was for testing the relative velocity of the earth and the ether. It was while he will still in Europe, at the age of twenty-eight, that he made his first try at this epoch-making experiment. He reports it in the *American Journal of*

Science, 22: 120 to 129, 1881. He had tried it first in Berlin, then moved to the Astrophysikalisches Observatorium at Potsdam. In his brief report he thanks Alexander Graham Bell for supplying the funds for the investigation, and is so confident of the correctness of the negative result obtained that he asserts that "The hypothesis of a stationary ether is thus shown to be incorrect."

It is not until 1886 and 1887 that this experiment, repeated at Case School of Applied Science with great care and refinement by Michelson and Morley, begins to take its place as the most famous and in many ways the most fundamentally significant experiment since the discovery of electromagnetic induction by Faraday in 1831. The special theory of relativity may be looked upon as essentially a generalization from it.

Only second to it in importance is the use which Michelson made of his interferometer, especially in the years 1887 to 1897, in proving, through his penetrating and very skilful study of the so-called visibility curves characteristic of different spectral lines, the great complexity of all save a very few of such lines. It was the analysis of these visibility curves which brought the discovery that the so-called red cadmium line of wave-length 6,438.472 angströms (an angström is a ten-millionth of a millimeter) is so extraordinarily monochromatic that it is desirable to express the length of the international standard meter in terms of it. At the invitation of the International Bureau of Weights and Measures, Professor Michelson, with his collaborator, Professor Morley, spent the year 1892 carrying through this very exacting undertaking, with the result that the number of the foregoing wave-lengths in this standard was determined as 1,555,165.5.

Under this head should also come the extraordinarily fine work on the application of interferometry to the measurement of the diameters of stars done at the request of Dr. George E. Hale and in collaboration with F. G. Pease at the Mount Wilson Observatory between 1920 and 1925, a measurement which, for the first time, made possible the direct determination of a stellar diameter, and, to take but one example, fixed the diameter of Betelgeuse at 240,000,000 miles—about a hundred times that of the sun. The essentials of the method had been published by Michelson as early as 1890.

V. Michelson, Spectroscopy and Geophysics

No event in Michelson's career showed the originality of his mind better than the echelon spectroscope, which appeared in 1898. Unlike the interferometer, the accomplishment of this instrument has not been large because of its very narrow spectroscopic range; but the idea of obtaining high resolution by using this particular means of getting into a spectrum of very high order was at the time so novel that spectroscopists the world over were surprised and delighted with it. It showed, too, how fundamental an understanding its author had of all the elements of correct spectroscopic design. Its appearance probably had much to do with stimulating the minds of Fabry and Perrot to attain high spectroscopic resolution by their modification of this route. This has found application to a somewhat larger number of problems.

The attainment of high spectroscopic resolution had by this time (1900) become a major objective with Michelson, and it was perhaps because he thought he had about exhausted the possibilities of the interferometer and the echelon for this purpose that he turned his attention to the problem that gave him more trouble and at the same time filled his associates with more admiration for him than any of its predecessors had done, namely, the problem of ruling very high resolution gratings. He had thought he could build a machine in a few months,

or at most a few years, which would give him the desired resolution, but he spent the rest of his life without reaching the point at which he was willing to drop the problem. He often said he regretted that he ever got "this bear by the tail," but he would not let go, and, in spite of endless discouragements, at the end of about eight years of struggle he had produced a good six-inch grating containing 110,000 lines (resolving power is measured by the number of lines times the order of the spectrum), which was 50 per cent. better than the best otherwise produced at that time, and in 1915 he produced both an 8-inch and a 10-inch, which are still "among the most powerful instruments of diffraction that the world possesses," although with the extraordinary developments of quantum and nuclear physics the problem has become so important for physics, astronomy, chemistry and even biology that a considerable number of institutions are now hard at the grating problem.

One of the finest things that Michelson ever said was inspired by his baffling experiences with his grating machines. It reads:

> One comes to regard the machine as having a personality—I had almost said a feminine personality—requiring humoring, coaxing, cajoling, even threatening. But finally one realizes that the personality is that of an alert and skilful player in an intricate but fascinating game, who will take immediate advantage of the mistakes of his opponent, who "springs" the most disconcerting surprises, who never leaves any result to chance, but who nevertheless plays fair, in strict accordance with the rules he knows, and makes no allowance if you do not. When *you* learn them, and play accordingly, the game progresses as it should.

The problem of the rigidity of the earth which Michelson, in collaboration with Gale, solved so magnificently in 1919 is unlike most of Michelson's work in that it was undertaken at the request of others, particularly the geologist, T. C. Chamberlin, who was intensely interested in knowing how rigid the earth as a whole is. If it acted throughout like a fluid, then the land would move just as does water under the influence of the moon and the sun, and there would be no water tides at all relative to the surface of the earth. Could not Michelson suggest and carry out a method of making an exact measurement? Michelson at once devised the following exceedingly simple and direct method which, however, save for the "fringe system" of measurement, had been suggested earlier, I think by Airy, though never actually tried. It consisted in burying about ten feet under ground two 6-inch iron pipes about 500 feet long, one running east and west, the other north and south, with an observation chamber at the junction point. The pipes were filled half full of water. The variation in the levels of the water at the ends of the pipes, as the moon and sun periodically produced their miniature tides in the water in these two pipes, were accurately measured by the movement they produced in a simple optical fringe system formed between the top of the water and a surface rigidly attached to the earth. The amplitude of the movement was from 6 to 11 microns. If the earth were not at all rigid, as already stated, there would be no relative movement of the earth and water in the pipes at all, and hence no movement of the fringes. If the earth were completely rigid the movement could be exactly computed from the pull of the moon and the sun. The movement was actually about half of that computed for an immobile earth.

These results, published in the *Astrophysical Journal* by Michelson and Gale for 1919, undoubtedly give the best values yet obtained of the earth's rigidity, as well as of its viscosity. The difficult tidal computations were carried out by F. R. Moulton, of the University of Chicago, and his staff.

VI. Michelson, the Artist

This sketch would not be complete without an endeavor to appraise some-

what more fully the artistic side of Michelson's personality. In a sense I have already paid the highest possible tribute to his artistry in describing the refinement and exactness of his measurements and the perfection of the design of his instruments, for are not discrimination in the choice of tools and methods and exact adaptation of means to end of the very essence of real art? Michelson was incessantly trying to perfect his artistic techniques, practicing his tennis strokes, taking lessons to improve his billiard shots. His students were continually commenting upon the perfection of the circles which in his lectures he drew with such ease on the blackboard. Is it at all strange, then, that he was interested in music and a good performer on the violin? The connection between his accurate analysis of spectral colors and his love of painting landscapes and seascapes is a little less obvious, but be that as it may, in Southern California, where he spent a considerable fraction of the last ten years of his life, he divided his time between scientific pursuits and painting expeditions to the beaches, arroyos and the High Sierras. In the summer of 1925, when I came down from a week spent studying cosmic rays in Muir Lake under the brow of Mt. Whitney, I found Michelson all alone seated with his easel in a favorable spot on the porch of the little Lone Pine Inn, painting the glorious view he had found there of the snow-capped Whitney. In other words, he not only had the skill of the artist but also the feelings of the artist. He wrote two papers in which he gave expression to these feelings; one written in 1906 is entitled "Form Analysis." In it he attempts a classification of symmetrical forms as they are found in nature, and expresses the delight he found in these discoveries. He made this analysis, however, rather as a recreation than as a serious study. The other paper, written in 1911, is on "The Metallic Coloring of Birds and Insects," and in it, while he has set himself the scientific objective of finding whether the iridescent colors found in birds and insects are due to pigmentation, interference or metallic reflection, he gives expression to the feelings aroused in him by these beautiful color effects found in nature. Also in a paragraph from the Lowell Lectures he uses the following words:

> The aesthetic side of the subject is by no means the least attractive to me. I hope the day is near when a Ruskin will be found equal to the description of the beauties of coloring, the exquisite gradations of light and shade, and the intricate wonders of symmetrical forms and combinations which are encountered everywhere.

In 1928, a few years before Professor Michelson's death, a conference on the Michelson-Morley experiment was held at Pasadena. It was a distinguished gathering, with both Lorentz and Michelson having a part in the program. The latter was scheduled to make a final report on the repetition he had just made on Mt. Wilson of this famous experiment. Roy Kennedy, a young physicist who had repeated this experiment at the Norman Bridge Laboratory in a new way and with much precision, preceded Michelson. With a generosity and courtesy altogether characteristic of him, Michelson rose and, complimenting Kennedy enthusiastically upon the beauty and precision of his experiment, said: "Your work, Dr. Kennedy, renders my own work quite superfluous. I should not have undertaken it had I known you were doing it so well." It was one of the finest tributes Michelson could have paid *to himself*—a wonderful ending of a wonderful career, for this was Michelson's last public appearance.

WHICH WAY SCIENCE?

By Dr. HARLAN TRUE STETSON
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SCIENCE finds itself in a strange dilemma. It has made life easier and added to man's happiness and at the same time, in the event of war, it clouds the future with unspeakable horrors. Science is so intricately woven into our social and economic existence that she is a goddess both worshipped and feared. Science has cut the cost of production until even hitherto luxuries have fallen into the "must" class of commodities for nearly all standards of living. The machine age which has followed in the wake of scientific discovery has created new industries and disrupted old ones, causing many social and industrial maladjustments.

There is no question that the world to-day is in the midst of a social, industrial and economic evolution of far-reaching consequences. No one can deny that science has had its part in creating and complicating the present world picture. The prestige which science holds in the minds of multitudes can not but impress those who labor in her laboratories with the power and the responsibility that is theirs in fostering the aims and methods of science for the welfare of mankind. What can science do towards the control and use of its products for the good and not the destruction of society?

While confronted with such a question, there is perhaps a note of encouragement in that recent events make clear that both the negative and the positive assets of science may work side by side to constructive ends. On the negative side, the very thought of the horrors of the wholesale destruction that science can connive in the event of war has undoubtedly been a strong deterrent from engaging in a conflict that might well bring about the very ruin of civilization itself.

On the positive side, we have had an exhibition in international affairs of the application of the spirit of science that teaches a rational rather than an emotional approach to any problem, substituting methods of trial and error for assault and battery. Furthermore, scientific inventions themselves played their part in bringing about a four-power pact that for the moment seems to have stayed a European conflict. In 1938 negotiations could be accomplished in an hour which two decades ago would have required delay that might have been disastrous. While the world waited breathless for the fate of Europe, transoceanic and international telephone lines brought diplomats into instant communication. Airplanes conveyed plenipotentiaries from nation to nation, while public opinion was being moulded by world-wide radio broadcasting that constantly informed the world of every development in the European crisis.

It is significant that with war clouds hanging over Europe representatives of the American Association for the Advancement of Science met with members of the British Association for the Advancement of Science last July to consider ways and means by which a closer affiliation between these large scientific bodies might be accomplished with the ultimate joint purpose of making science a more dominant factor in guiding the destiny of world affairs.

These associations represent as no other organization the united front of science in the United States and in the United Kingdom. It is perhaps a bit unfortunate that our own American Association has too long been considered by many scientists as an aggregation of technical associations, each quite sufficient unto itself. But the hope is stirring

that in its various attempts to arrange conferences on science and society the scientists who compose our association will become aware of their civic responsibilities, which are fast becoming apparent whether we wish or do not wish to have our researches interrupted by such distractions. Most creative minds are probably by nature largely introvert. This may account for the painful lack of any unified action on the part of scientific men to leave their cubicles for the arena. The present trend of world events suddenly awakens us, however, to the fact that unless those who have created the offspring of science unite to guide and educate the masses in the spirit of science to a larger degree than has at present been done, research men may be suddenly awakened to find their laboratories in ruins and the dreams to which they had devoted their lives lost in the smoke of the impending chaos of a world struggle.

Five years ago at its meeting in 1933, the American Association passed a resolution framed by Drs. Robert A. Millikan and Henry Norris Russell which read as follows:

> Our existing liberties have been won through ages of struggle and at enormous cost. If these are lost or seriously impaired there can be no hope of continued progress in science, or justice in government, or international or domestic peace, or even of lasting material well-being.
>
> We regard the suppression of independent thought and of its free expression as a major crime against civilization itself. Yet oppression of this sort has been inflicted upon investigators, scholars, teachers and professional men in many ways, whether by government action, administrative coercion or extra-legal violence.
>
> We feel it our duty to denounce all such actions as intolerable forms of tyrrany.
>
> There can be no compromise on this issue, for even the commonwealth of learning can not endure "half slave and half free." By our life and training as scientists and by our heritage as Americans we must stand for freedom.

While such a notable declaration of scientific freedom is seconded by every true scientific worker throughout the world, it is primarily a protest and denunciation of infringements of liberty, leaving a constructive program for remedial action still to come. In urging some concrete action, Watson Davis in writing in *Science News Letter* for October 2, 1938, says:

> If science is to rescue the society it has created, and if the world at large is to preserve in freedom and tolerance the intellectual urge that gives it continual rebirth, there must be some mechanism, whether organized or not, that makes this possible.
>
> Whether the new science movement takes the form of a new intellectual brotherhood, a new political party, or an infiltration into existing progressive movements, it must be articulate, self-assertive, and combative within the limits of the scientific method. It must become a crusade with truth as its only dogma.

The great "intellectual brotherhood" to which Mr. Davis refers does exist among scientific workers not only in this country but throughout the world. Nothing is more apparent when scientists meet in international congresses than the fact that political, racial and social differences are forgotten in the eagerness to discuss the aspects of a common scientific problem in which workers throughout the world may be engaged. Much undoubtedly can be done to further filial relationships among scientists. If, on the other hand, a world conflict starts up on the aggressive move of any totalitarian state, we can rest assured that it will not have been brought about by members of the brotherhood of science. But some factor more effective than that of filial interests alone must become apparent.

Mr. Davis's suggestion that a new political party with which scientists as a body might become affiliated would, I believe, be unfortunate and unworkable. Science which recognizes no political barriers, races nor creeds can not afford to ally itself directly with any political party as now exists or that appears likely to exist.

Mr. Davis's suggestion of "an infiltration into existing progressive move-

ments" appears to be a particularly happy phrase. No political party gains control or stays in power, and no dictator rules except ultimately in accordance with the will of the people. It must never be forgotten that public opinion is the last court of appeal. The unfortunate fact is perhaps that public opinion is more easily moulded by political speech-making than by the colder rational application of the scientific method of thinking. This is perhaps partly our own fault. Too long have too many scientific men held aloof from the world of affairs. Too long, perhaps, have we been concerned with guarding our standing among academic intellectuals while ignoring the people whose majority vote rules in a democracy and whose subservience is necessary to any dictatorship.

Fortunately, much has been done in recent years to "infiltrate" the doings of science into the reading of the general public. An increasing number of scientists are sharing with the rank and file the results of their labors, even at the risk that inadequate statements may be circulated by the press at the expense of a certain prestige among colleagues who fail to understand the need for popularization of science. There is indeed a need for far more popularization of science in still plainer language—not for the unintelligent but for the vast majority of intelligent people who make up the nation but to whom scientific terminology is as non-understandable as is the vocabulary of the medical profession to the architect or the engineer. Science, which depends for its existence upon public good will and, in the end, public financial support, can well afford to keep the world constantly informed of its achievements other than in technical language. Perhaps the day will come when every editor of a scientific journal shall request in addition to the technical manuscript a paraphrased summary in ordinary English recounting the significant results of each piece of research. This might incidentally help a scientific worker to evaluate the significance of his own contribution to the society in which he dwells.

The chief of each bureau is probably the one who best knows the needs and requirements for the maintenance and normal progress of scientific investigations in his field. Each bureau chief must present his requirements yearly to Congress through the director of the budget, a political appointment often excellently made, but without reference to scientific training or experience. The incumbent of this office must pass on the relative merits of the appropriation proposed with the result that all too often appropriations may be unnecessarily augmented or painfully curtailed, depending upon the ability or lack of ability of salesmanship on the part of the chiefs of bureaus. While certain of the bureaus have the advantage of advisory bodies comprised of highly trained scientists and engineers, why is there not a responsible officer of the government or a board selected from among scientific men whose training and experience would allow a satisfactory evaluation of the relative merits of all the scientific projects that the government controls? To such an officer or board, chiefs of bureaus might appeal with the assurance of an adequate hearing of their needs and proposals.

To be sure, in the history of the country three boards have already been created that presumably should act in an advisory capacity to the government in scientific matters—the National Academy of Sciences, the National Research Council and the Science Advisory Board.

The National Academy of Sciences was called into being by President Lincoln in 1863 at the time of national emergency. It was incorporated by Congress to report upon matters in science and art.

whenever called upon. The academy has frequently been of service to the government in our national history.

In 1916, under the administration of President Wilson, the National Research Council was organized, largely through the efforts of the late Dr. George Ellery Hale, to act as an advisory body in scientific matters, again in a time of national emergency. Ostensibly its function still exists, though it is seldom called upon for advice by the government.

With the inauguration of the New Deal Administration under President Roosevelt, a new kind of national emergency existed, and a Science Advisory Board was called into being to implement the functions of the National Research Council and to advise the government relative to the administration of its scientific bureaus. The excellent report by its chairman, Dr. Karl T. Compton, was distributed in December, 1934. It was noteworthy that most of the recommendations made by this advisory board as to specific questions raised by the government were acted upon favorably. However, additional recommendations, initiated by this Science Advisory Board, though of far-reaching significance, were not acted upon. Is advice on scientific matters by the national administration needed only in times of emergency? When a body of scientific men has been created by the government for scientific advice, is it inappropriate that they proffer advice except on questions specifically framed by the administrators themselves? When a new administration comes into being in Washington, or a new emergency arises, will it again be necessary that another advisory body of scientists be created as though such establishments that have already come into being through executive order did not exist? What is wrong with our scientific organizations that such should be necessary?

When scientific problems arise of national and international concern and of sufficient importance to make government cooperation desirable, it is indeed most unfortunate if the National Academy of Sciences, the National Research Council or the Science Advisory Board can take no initiative under a democratic government in approaching our federal administrators in such matters. Is there not opportunity here for science to unite in action, and through the creation of an intelligent public opinion make possible the continuation of an effective advisory board for science which shall have direct access to the federal authorities with the same assurance of recognition accorded it on occasions when advice is sought?

Have scientists perhaps been at fault that the present situation exists? Administrations come and go, but the National Research Council, with much the same organization, has continued on under Presidents Harding, Coolidge, Hoover and Roosevelt. Through these political vicissitudes the preservation of the dignity of the National Research Council has never been challenged, but can this representative body of scientists in its peculiar relation to the Federal Government continue to expect that overburdened officials carried in and out of office through the ebb and flow of the political tides will recognize the importance of science in our society, or the existence of the National Research Council in its capacity to advise, if nothing whatever is done about advising them of its existence?

Why should not the guardians of the faith of science take the initiative with each change of administration and through suitable approaches see to it that the council is brought into as close a contact with the government administrators and representatives as is the case with leaders of labor and of industry? If the dignity of science forbids, then science might well exchange something of its dignity for a political recognition that would assure as much prestige in national affairs and as intelligent a welcome

to officialdom as is granted commercial, industrial and labor organizations throughout the United States.

The aggregate expenditures for scientific research, including federal, departmental, state and private educational institutions, and our industrial laboratories taken together represent so significant an enterprise in this nation that it should command the attention of every Senator, Representative and taxpayer in the country. Public opinion could bring this about if scientists as a body were aroused to action.

The question of some form of federal control of public health, socialized medicine and a plan for hospitalization insurance has already attracted wide publicity. It has agitated the whole medical world. If such progressive movements are to take place, what is to insure that such federal control shall be above political propaganda? This is but one instance where there is a growing consciousness of a new relation of government to matters of science. Any plans covering medical or other scientific activities should be worked out with due deliberation to insure an intelligent control, irrespective of party or political affiliation.

The education of public opinion is a long and tedious process. But the patient and persistent efforts of a united scientific body towards this end should be fruitful of results in due time. If a little more than two decades is needed to train for military purposes a new generation, then the same amount of time spent in an organized effort for education in scientific intelligence would work wonders. So often has the teaching of history, literature and allied subjects so glorified the results of military achievement that rising generations learn too easily to place undue emphasis on this phase of social progress. When scientific achievements and the men who have pushed back the barriers of knowledge have been given an equal emphasis, a far greater proportion of hero-worshippers among our youth will find their heroes in science.

One can not but wonder that the teaching of science in our schools and colleges may have been guided all too much by emphasis upon the technicalities of the subject rather than by the experience and methods of science as applied to clear thinking and to developing a true basis for a sense of values. When one finds a science requirement in the curriculum irritating to a pupil who makes use of radio, automobile, airplane and many other devices of science and engineering, one wonders where the fault lies. From such reports that come in from overseas one would think that the Union of Soviet Republics was far more progressive in the scientific education of youth than is the United States of America.

Through a new emphasis in educational curricula and a further and more extensive popularization of science among peace-loving nations, one might expect that economic and political differences would become more easily adjusted. Nations would unite in the conquest of the frontiers of knowledge. One is indeed a pessimist to think that the present accomplishments of science are other than the beginning of a national prosperity such as civilization has yet to see. Such new trends of emphasis together with a more direct impact of science upon governments could accomplish much in the next two decades. Many of the problems of science to-day can not be solved except through the cooperation of workers in various fields of science, and there are many scientific problems which must wait for solution upon international cooperation alone.

In September, 1939, there will meet in Washington a congress of scientists which will be the first of its kind to meet in this country by invitation of the President of the United States. The occasion will be the seventh assembly of the International Union of Geodesy and

Geophysics, a scientific body comprising thirty-five adhering nations devoted to increasing our knowledge of the earth. To quote Professor Longwell, of Yale:

> Probably no scientific association covers a broader field of interest than the Union of Geodesy and Geophysics. The Union is made up of seven constituent associations, devoted to geodesy, seismology, meteorology, terrestrial magnetism and electricity, physical oceanography, volcanology, and hydrology. Physicists, geologists, geographers, and many types of engineers, in addition to specialists representing some of the particular fields suggested in names of the associations, find a common meeting ground in the Union, which owes its origin and its continued growth to the interlocking problems crossing the borders of the several physical sciences in all of the countries. The meetings of the Union, held at three-year intervals, not only promote international cooperation in scientific enterprises but also help materially to foster international good will.

There is probably no field of scientific endeavor so dependent upon international cooperation as this field of the earth sciences. There are many international unions such as of astronomy, mathematics, applied mechanics and engineering, sugar cane technologists, etc. None of these is so dependent upon international cooperation as that of the sciences of the earth. It is desirable, for example, in particular problems of astronomy that we have the cooperation of observatories scattered around the world. Activities on the solar surface are lost to us while the sun is below the horizon, and the record of light changes of certain variable stars would be broken if observers on the other side of the earth did not clock their behavior while they are below our own horizon. International cooperation makes possible the establishment of observing stations in the southern hemisphere for gathering data on stars invisible in the northern hemisphere. But to a very great extent, we can observe stars in our own country that are observed twelve hours later on the other side of the world.

When it comes, however, to be a basic study of weather or continental and oceanic structure of the earth on which we live, we are at a complete loss for fundamental data in regard to this planet and its atmosphere, did we not have knowledge gleaned by scientific methods from those countries where important territories of this globe are entrusted to other governments than our own. It is significant that in spite of European turmoil, an invitation can be issued in the summer of 1938 by the President of the United States through the Department of State to send representatives of thirty-five nations for the consideration of fundamental problems in the earth sciences that recognize no trade barriers, no political differences or racial demarcations. With the emphasis of nations resting upon matters of such fundamental importance to our economic existence, science is fostering an international good will that we can confidently believe postponed in no insignificant way the day of strife.

The American Association for the Advancement of Science, organized in 1848, is the oldest truly representative national scientific society in the United States. To quote Dr. Moulton, permanent secretary of the association:

> It is the federation of the most important forces, at least in the long run, that are operating on the continent. It is demonstrating that the whole of science is greater than the sum of its parts. . . . The voice of the association is increasing. The combined voice of science in America. . . . The association has more than 18,000 members and the membership of its affiliated societies (including duplications) is approaching a million.

It may well be that the American Association for the Advancement of Science is the logical body already organized competent to act upon such of the measures as we have been discussing above. There is need for action. Which way will science go?

SCIENCE IN VIRGINIA

By WILLIAM H. WRANEK, JR.
UNIVERSITY OF VIRGINIA

VIRGINIA, host to the American Association for the Advancement of Science for the December, 1938, meeting, is more widely known for the achievements of her sons in the field of statecraft and politics than for her contributions toward the development of the natural sciences.

Early colonizers were absorbed in making a living in a wilderness. Few could spare time to study, to write notes and to draft reports on their new-found land. It was enough to produce necessities, and perhaps a cash crop of tobacco. Scientific investigation was not for them. Berkeley, one of the early royal governors, gave thanks that there were no free schools in the colony. When the sons and grandsons of the settlers had moved from the stockades of Jamestown to the brick and stone of Williamsburg and later of Richmond they were preoccupied with making a democracy, and their speculations had more to do with the relationships of man with man than with the nature of the world about them.

Of the Virginia founding fathers who strove to better man's position Thomas Jefferson was the one who gave most serious thought to the natural sciences. Jefferson was not content with freeing the mind and spirit of man; he wanted to give him a better world in which to live and to enjoy that freedom, to provide more comfortable dwellings and a more varied and prosperous agriculture and industry, to increase man's health and happiness.

When, in his latter years, Jefferson founded the University of Virginia he enumerated the advantages of the higher grade of education, one of which was to enlighten the citizens "with mathematical and physical sciences, which advance the arts, and administer to the health, the subsistence and the comforts of human life." The curriculum he proposed and saw established at his university in 1824 included all the natural sciences.

In 1797 Jefferson was elected president of the American Philosophical Society, which had been formed in Philadelphia years before, and when he took office he was one of eighteen Virginians who had become members of this society "for promoting useful knowledge."

One of the Virginia members of this young organization, James Rumsey, was making practical use of the power of steam, and on December 11, 1787, a steamboat constructed according to his plans carried passengers across the Potomac River, making a speed of four miles an hour against the current.

In the Shenandoah Valley, in two adjoining counties, the grain reaper was first devised by Robert McCormick and was perfected by his son, Cyrus McCormick, and a chain-stitch sewing machine was invented by James E. A. Gibbs. Chemical studies carried on by John William Draper, while he was a professor at Hampden-Sydney College, led to the taking of the first photograph ever to be made in America and of the first photograph of a human face ever to be taken.

The name of Matthew Fontaine Maury, "pathfinder of the seas," is forever linked with ocean navigation and transatlantic communication as the names of Walter Reed and Henry Carter are with the development of preventive medicine. John W. Mallett, Thomas Jefferson Page, Elisha Kent Kane, Charles S. Venable, Benjamin S. Ewell, William Morris Fontaine and Jed Hotchkiss are other and less widely known Virginians who la-

bored to advance science during the nineteenth century.

William Barton Rogers, who became the first president of the American Association for the Advancement of Science when this society was formed in 1848 and whose memory is to be honored at the December meeting of the association, was appointed in March, 1835, to be the first state geologist of Virginia. He was teaching at the College of William and Mary, and he transferred to the University of Virginia, where he served as professor of natural philosophy until 1853. The failure of the Virginia General Assembly in 1841 to continue its appropriation for the Geological Survey resulted in the abolition of his office as state geologist, but as university professor he continued his studies in the fields of physiography, mineralogy, petrology, economic geology, stratigraphy and paleontology.

He left the University of Virginia to go to Cambridge, Massachusetts, where he became the first head of the Massachusetts Institute of Technology. The reports that he published and the papers he left behind him when he went to Massachusetts, which were edited by Major Hotchkiss, war-time topographic engineer for General Stonewall Jackson, and which appeared in the six volumes of "Geology in Virginia" between 1880 and 1885, led to a wider appreciation of the scientific possibilities and opportunities of the Old Dominion.

William B. Rogers and his brother, Henry Darwin Rogers, made extensive field observations in the Virginia Appalachians. Professor Rogers died in 1882, and eleven years later there was built at Saltville, in the heart of these uplands, the first plant of the Mathieson Alkali Works. This was a forerunner of the great industrial movement that has spread through Virginia during the first three decades of the twentieth century.

From small beginnings there has been swift development, and now almost every phase of modern scientific industry can be found within the Old Dominion. The banks of the James, the York and the Rappahannock, where generations of planters lived on their broad acres, are now fringed with plants for the manufacture of paper, of cellulose fabric and other products of industrial chemistry. Inland villages have boomed and mountain valleys have taken on unaccustomed activity almost over night. And behind each step in this expansion of industry is a story of long and careful scientific investigation, most of it carried on in secret and protected by patents.

A century has gone by since Dr. Rogers founded the Virginia Geological Survey, but it has been largely through the efforts put forward by this agency since its revival in 1908 that the mineral wealth of the Old Dominion has become known. Under the direction of the late Thomas L. Watson, of Wilbur A. Nelson and now of Arthur Bevan, the Geological Survey has sought to discover the important facts concerning the geology and mineral resources of the commonwealth and to publish accurate reports of its findings.

During recent years about forty different kinds of rocks and minerals have been quarried and mined in Virginia for commercial use, and through the last quarter century the mineral production of the state has totaled roughly one billion dollars. In addition to the publication of reports the Virginia Geological Survey has for the last twenty-five years cooperated with the Federal Government in an extensive program of topographic mapping.

When Jefferson established his university he planned for the teaching of astronomy and went so far as to prepare for an observatory on top of a little mountain west of Charlottesville. But there was no money to carry out the project nor could the needed amount be raised

when it was proposed, in 1866, to bring Commodore Maury from the Virginia Military Institute to the university as professor of astronomy.

Leander McCormick, son of Robert and brother of Cyrus McCormick, presented to the university a refracting telescope of 26 inches aperture and 32½ feet focal length which was, when the observatory was opened in 1883 with Dr. Ormond Stone as director, the largest and finest in the whole world. This distinction it held for only a few years, but it remains to-day the largest refractor in the eastern United States.

Twenty-five years ago, in 1913, Dr. S. A. Mitchell, came from the Yerkes Observatory and from Columbia University to succeed Professor Stone. At the Yerkes Observatory he had been engaged in the measurement of the distances to the stars by photography and he began plans to continue this work at Virginia. The photographic work was started at the McCormick Observatory in the autumn of 1914 and since then more than 41,000 plates have been taken. In this project Dr. Mitchell has had the support of such colleagues on the staff as Dr. Charles P. Olivier, now director of the Flower Observatory; Dr. Harold L. Alden, now in charge of the Yale Observatory in Johannesburg, South Africa; Dr. Peter van de Kamp, now director of the Sproul Observatory, and of his present associates, Dr. Alexander N. Vyssotsky,

THOMAS JEFFERSON, BY THE LATE KARL BITTER

Dr. Dirk Reuyl and Dr. C. M. Anderson, Jr.

Although about ten of the great observatories are engaged in the project, the McCormick Observatory is one of three observatories measuring the greatest number of stellar distances. At the fall meeting of the National Academy of Sciences Dr. Mitchell reported on the determination of the distances of 1,350 stars by the trigonometric method. All bright stars in the sky north of 20° south declination and irrespective of color have had their distances measured. The present working program of the McCormick staff consists chiefly of measuring faint stars of large proper motions.

From the large collection of photographs made by the 26-inch refractor the proper motions of 18,000 stars have been determined and published. From this abundant material there was found the motion of the sun with respect to stars of different magnitude and different color, the rotation of the galaxy in 200,000,000 years and the constants of the precession of the equinoxes. It has also been possible to determine the magnitudes of 8,000 sequence stars to be used as comparison stars in determining the brightness of 450 variable stars of long period.

Dr. Mitchell is perhaps the world's foremost observer of solar eclipses, and he has traveled many thousands of miles to observe ten total eclipses. He had served for seven years as president of the commission on parallaxes and proper motions of the International Astronomical Union when, in 1935, he gave up this office to become president of the commission on eclipses. He was reelected head of this commission at the last meeting of the union in Stockholm.

An important new apparatus for attacking problems in chemistry, physics, biology and medicine is the ultracentrifuge developed in the Rouss Physical Laboratory of the University of Virginia by Dr. Jesse W. Beams. He and his associates have found that they can spin these rotors as fast as 21,000 revolutions a second, and that their speed is limited only by the strength of the material from which they are made. Compressed air and hydrogen have been used to spin the rotors until the centrifugal force generated is 8,000,000 times gravity. More recently electrical force has been used for supporting and spinning these rotors.

When spun inside a vacuum chamber the ultracentrifuge is not subjected to friction from the air, and because no heat is generated materials being centrifuged inside the rotors do not undergo remixing. Dr. Beams is using this apparatus for the separation of isotopes, and in the University of Virginia Biochemistry Laboratory Dr. Alfred Chanutin and his assistant, Dr. Victor Masket, have applied the ultra-centrifuge to researches in viruses, hormones and enzymes. Men trained at the University of Virginia and instruments developed there have found their way into leading scientific and industrial laboratories in this and other lands.

In the Rouss Laboratory Dr. Leland B. Snoddy has been making studies of high-voltage electrical discharges in gases. He began by studying these phenomena in the laboratory, but he has included a study of lightning, and during the last two summers he has made visits to Churchill, in the upper Hudson Bay country, where he has extended his investigations to the aurora.

Seven Virginia colleges and universities are cooperating on a chemical research project that has recently been started under the supervision of Dr. John H. Yoe, of the University of Virginia, who is engaged in a search for new organic reagents for use in inorganic analysis and in studying the relationships between the molecular structure of organic compounds and their analytical reactions.

Cooperating in this work are Professors W. J. Frierson, of Hampden-Sydney

College; Lucius J. Desha and John R. Taylor, of Washington and Lee University; J. W. Watson and F. H. Fish, of Virginia Polytechnic Institute; I. A. Updike, of Randolph-Macon College; William E. Trout, of Mary Baldwin College, and A. R. Armstrong, of the College of William and Mary. Already about 1,200 compounds have been studied, and more than 150 separate tests have been made with each compound.

Another cooperative project in chemistry, one that has been under way for several years and that has attracted wide-spread attention, is the intensive endeavor to find new organic substances with analgesic properties but without habit-forming effects. This investigation has been supported by the National Research Council and has been directed by Dr. Lyndon F. Small, who this year has sixteen men working with him at the University of Virginia. Scientists at the University of Michigan and in four departments of the Federal Government are joining hands in this work.

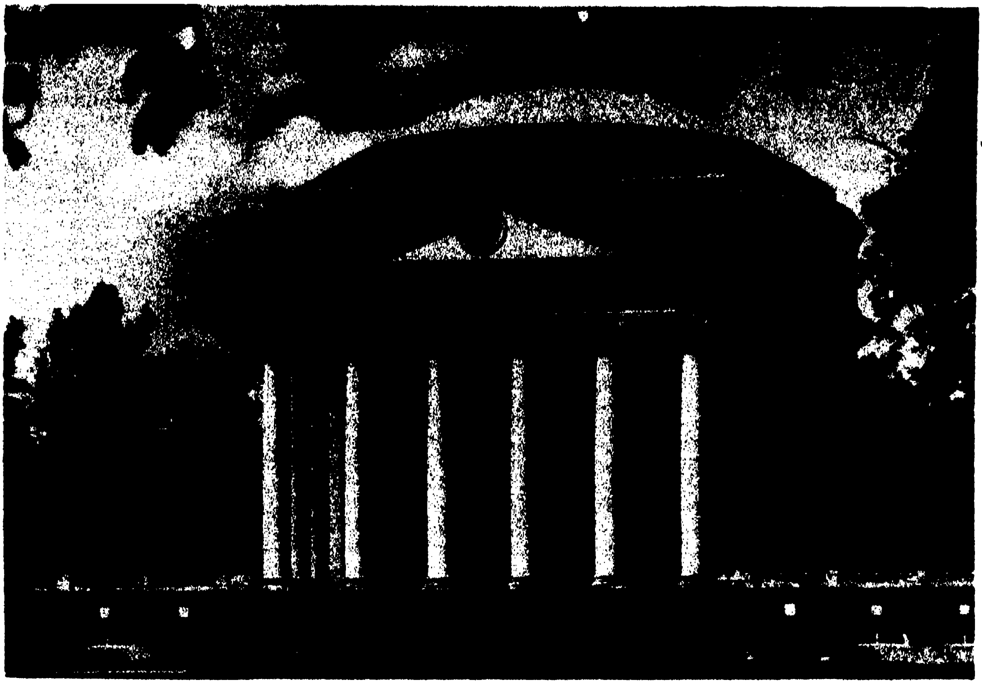
In the field of biology the University of Virginia carries on activities at three separate locations. Within the Biological Laboratory at Charlottesville the study of flatworms being made by Dr. W. A. Kepner and his associates has resulted in the discovery of many new species. At the Norfolk Division of the College of William and Mary, Dr. E. Ruffin Jones is at work on a correlated study of marine flatworms.

At the Blandy Experimental Farm, which the university operates near Boyce, investigations into the cytogenetics and the cytotaxonomy of various groups of plants are being conducted by Dr. Orland E. White and a group of research fellows. Studies are also in progress on the longevity of plants, the prevalence of variations in wild plant species, and on the relation of geographical distribution, mutation and the resistance of plants to low temperatures.

For nine summers a Biological Station has been conducted at Mountain Lake under the direction of Dr. Ivey F. Lewis.

WEST LAWN OF THE UNIVERSITY OF VIRGINIA

SHOWING THE FIRST OF THE ORIGINAL PAVILIONS DESIGNED BY THOMAS JEFFERSON FOR FIRST FACULTY MEMBERS, WHO LIVED UPSTAIRS AND TAUGHT DOWNSTAIRS. STUDENTS HAVE LIVED IN INDIVIDUAL ROOMS ALONG THE COLONNADE FOR MORE THAN A CENTURY.



THE ROTUNDA, DESIGNED BY THOMAS JEFFERSON
WHO ADAPTED IT FROM THE ROMAN PANTHEON TO BE THE CENTRAL BUILDING OF HIS "ACADEMICAL VILLAGE," THE UNIVERSITY OF VIRGINIA.

Students and investigators from the southern states and from some eastern universities are in residence during ten weeks each summer. Dr. Paul R. Burch, of East Radford State Teachers College, is conducting a survey of the animal life of Virginia, especially of the Alleghany region. Dr. L. R. Cleveland has published an investigation of the symbiotic flagellates of the wood roach, an important study in relation to termites and their activities. Dr. D. R. Hostetter, of Harrisonburg, is completing an exhaustive study of the Carolina junco, perhaps the most complete account of the life history and habits of any southern bird. Other studies of wide variety are in progress, including the ichthyology of the James River and the Ohio River drainage areas, which lie on either side of the divide at Mountain Lake.

In the commonwealth there are two centers for medical research, the Department of Medicine of the University in Charlottesville and the Medical College of Virginia in Richmond.

At the risk of making this seem a catalogue of University of Virginia activities a few medical projects must be mentioned. Probably the best known to members of the American Association for the Advancement of Science is the visual and photographic study of living nerve and muscle cells by Dr. Carl C. Speidel, who received the $1,000 prize of the association at its New Orleans meeting for his initial investigations in this field. Other medical studies include investigations of the ductless glands in the Physiological and in the Biochemical Laboratories, surgical work on pressures developing within the brain and spinal cord, the control of blood pressure, and experimental studies of allergy and allergic diseases. Others, equally important, might be named, but space does not permit.

Among many of the important contri-

butions to medical knowledge made by members of the staff of the Medical College of Virginia may be listed: the extensive work by the Department of Bacteriology on the liquefaction of gelatin by bacteria and on the isolation and identification of pathogenic fungi and the studies on insecticides, the glycols and the standardization and action of digitalis preparations by the Department of Pharmacy. The composition of alveolar air and factors affecting it as well as the physiology of muscular contraction and photosensitization have been attacked with considerable success in the Department of Physiology.

In other departments at Richmond work has been carried out on the effect of various stimulations on the sympathetic nervous system, the prevention of liver damage from the administration of various toxic substances, the interrelation and dependence on each other of the lung, blood, heart and certain secretory organs, especially their mutual chemical interdependence and regulation, and also the experimental production of lipoidoses, botriomycosis and certain types of nephritis.

In the clinical fields due emphasis has been given to the improvement of the routine care of patients, as well as to the investigative side of clinical problems. Much interest has been shown in the discovery by Minot and Murphy in the treatment of pernicious anemia, and a considerable number of original observations have been made and reports of these have appeared in national journals. In the last several years the investigative work has concerned itself with the physiological adjustments occurring in anemias, arteriovenous fistulae, in pregnancy and in other conditions which throw an excessive load on the cardiovascular apparatus. The availability of a large amount of clinical material in the Negro race has stimulated research in comparative physiology and the variations of the reaction to disease in the Negro.

The Medical College of Virginia has a large hospital for colored patients, and this has provided the Surgical Department with an exceptional opportunity to study the diagnosis, treatment and the prognosis of heart wounds.

In the Department of Dentistry considerable study has been carried on in regard to the histological changes in teeth due to plastic filling materials. Reports have been published on the subject showing the varying effects of different types of fillings on the histological structure of the teeth. In the field of prosthetic dentistry an effort has been made to show that a greater understanding of the biological laws of the dental system is necessary in the construction of artificial restorations. Certain natural forces that are of direct importance to the prosthodontist originate in the dental system and the fact that these forces arise from living tissue gives to this work a biological aspect.

Within scientific laboratories of Virginia there are more than a thousand workers, most of them with college or university affiliations. Undergraduate or professional instruction constitutes the most important work of the majority of them, but almost every one finds opportunity for specialized investigations. To list merely the names and research activities of these would be impossible, but some typical projects should be considered.

At the Virginia Polytechnic Institute the Department of Chemical Engineering is at work on several problems in the field of farm chemurgy. Two studies on soybeans are in progress; an experiment is being made in the use of the entire cotton plant, stalk, leaves, boll and lint, as a basis for synthetic lumber, improved methods of drying and curing tobacco are being investigated, and laboratory information on the utilization of peanut hulls is being sought.

The Virginia Agricultural Experiment Station, with headquarters at Blacksburg

and with ten sub-stations scattered over the commonwealth, has a staff of some 60 scientists at work on 150 major studies ranging all the way from the control of destructive tobacco blue mold to the substitution of lard for butter in making cakes, from flower garden soil studies to methods of controlling the ever-present codling moth.

Dr. A. D. Pratt, in the Dairy Husbandry Department at the Virginia Polytechnic Institute, has found that pasteurization of milk in an atmosphere of carbon dioxide prevented destruction of vitamin B_1 and produced a high vitamin C content. The blue mould or downy mildew fungus, which wiped out seedling tobacco plants over a wide area in 1932, 1933 and 1937, has been conquered by plant pathologists under Dr. S. A. Wingard, working in cooperation with Duke University. Animal pathologists have been tracing the life history of the black fly, which breeds in the larger streams of southwest Virginia and whose bite transmits a disease which has taken heavy toll in the turkey industry. At one sub-station the varying tolerance to arsenic of codling moth larvae from sprayed to unsprayed orchards is being studied.

The Virginia Cooperative Wildlife Research Station, being conducted under the direction of Dr. I. D. Wilson, head of the department of biology at the Institute, is under the joint auspices of the federal and state governments and of the institute. It is one of eight wildlife stations in the United States. The wild turkey is the center of a study which is considering food, cover, diseases and methods of restocking. Deer, quail, grouse and other game birds and animals are also being observed by C. O. Handley, A. B. Massey, C. F. De La Barre and others.

The Engineering Experiment Station at the Virginia Polytechnic Institute conducts investigation in professional and industrial fields and has recently completed an extensive analysis of the rainfall and stream flow of Virginia in which use has been made of data which has been accumulated over half a century or more.

Dr. Donald W. Davis, of the College of William and Mary, has been for years breeding balsam in carrying forward a thoroughgoing test of the Mendelian laws of heredity. In his investigation of behavior of species he has found most striking variations in flower colors.

At Washington and Lee University one of the most interesting projects is the study being done by the Geological Department on the origin of the Natural Bridge and of the various rocks in the Shenandoah Valley, including deposits of heavy minerals in these rocks. Dr. H. M. Stowe and Dr. E. C. H. Lammers have also been engaged in summer work on Rocky Mountain structural geology.

In the Biological Department at Lexington some workers have been studying the life history and control of the tarnished plant bug in celery, while others have been investigating mineral metabolism in experimental tuberculosis. In the Chemical Department work has been in progress for several years on textbook preparation and verification, and two volumes have recently been published.

This survey of the scientific investigations now going forward within the Old Dominion is all too incomplete. It is not intended to be a comprehensive coverage of the subject, but rather to show, by pointing first here and then there, that the research spirit has permeated every corner of the commonwealth and to give an earnest of the warm and understanding welcome awaiting those who come to Virginia for the 1938 meeting of the American Association for the Advancement of Science.

THE RECENT HURRICANE IN NEW ENGLAND[1]

By I. R. TANNEHILL
CHIEF OF THE MARINE DIVISION, U. S. WEATHER BUREAU

THE hurricane that wrought such devastation in New England on last September 21 originated as a tropical cyclone about 12 days before, presumably in the region of the Cape Verde Islands, thence traveled westward, as storms of this origin do, to near the West Indies, then curved northward, crossed New England, and faded over eastern Canada. Although this great storm, during its charted history, traveled about 3,000 miles, its destructive effects were confined almost altogether to Long Island and the New England States. Such storms have occurred before; some of them have sent many ships to the bottom in the open sea, but the modern steamship, with information and warnings by radio, is seldom in serious danger. Boats along the coast, seaside structures and property in the adjacent interior can not be adequately protected from the fury of a great hurricane. Its destructive effects are owing to the winds, which come in vicious gusts, to the torrential rains, which cause floods in the rivers, and to the rise of the sea along the coasts due to the driving force of the winds and the reduction in atmospheric pressure.

How such storms originate is not definitely known. Certain conditions which exist almost universally over the surface of the ocean during the formative period, namely, frequent showers, light winds and warm, moist air, are thought to be necessary for their development. These conditions are frequently found in or near the doldrums, which is the belt of calms lying along the heat equator between the trade wind systems of the two hemispheres. Observations during the birth of a tropical cyclone show that unsettled, showery weather with a

[1] The photographs on pages 42, 44, 45, 48 and 49 have been furnished through the courtesy of Carl Zeiss.

Photo by Dr. H. O. Sands

THE COLLAPSE OF BUILDINGS SHOWN ABOVE IS TYPICAL OF THE FORCE OF THE WIND NEAR CHARLESTOWN, RHODE ISLAND.

SURF AT WOODS HOLE, MASS.
TWO HOURS BEFORE THE STORM REACHED ITS MAXIMUM INTENSITY.

gradual inflow of air takes place over a relatively large area, usually involving thousands of square miles. Because of the effect of the earth's rotation, the winds, which would otherwise flow directly toward the center, are deflected to the right, in the Northern Hemisphere (to the left in the Southern), and a cyclonic wind system is thus established.

Obviously, a complete explanation of the genesis of a tropical cyclone must rest upon a knowledge of what takes place in the atmosphere above the earth's surface; the information available at present is inadequate for this purpose.

Some of these incipient disturbances quickly grow into violent tropical storms, others increase in force more slowly, while many of them do not develop anything more than mild wind systems with unsettled, squally weather.

Soon after its formation in the tropics, the cyclone begins to move. The generally accepted explanation is that the tropical storm moves with the general drift of the air masses in which it lies. In tropical regions this general drift is toward the west, but as the cyclone arrives in higher latitudes, usually about 20° to 30° from the equator, it is likely to turn more abruptly away from the equator, slowing somewhat at the turn and then progressing more rapidly to higher latitudes, but there have been numerous exceptions; many of them have continued on a westerly course without any recurve.

Various names have been given to tropical cyclones in different parts of the world. Those of the North Atlantic Ocean are generally called West Indian hurricanes. In the Bay of Bengal they are called cyclones; in the western North Pacific Ocean they are known as typhoons.

West Indian hurricanes usually diminish in force on moving out of the tropics, but there have been some notable exceptions, of which the New England hurricane of last September is an outstanding example. In the present century 13 cyclones of tropical origin have crossed New England and about as many others have traversed the ocean within 50 miles of Nantucket. Nearly half of them had developed full hurricane inten-

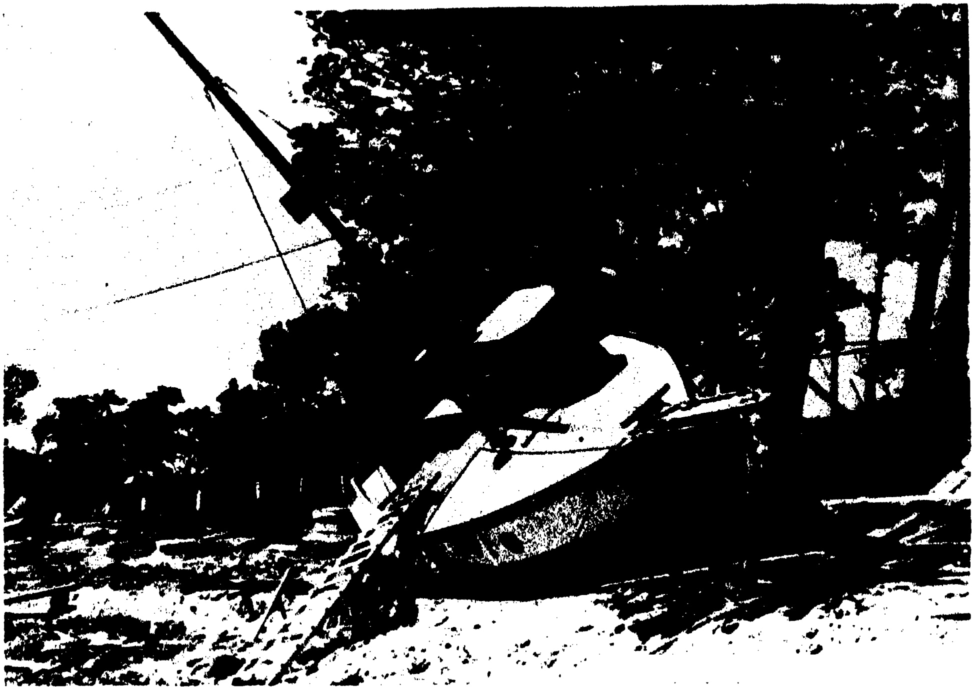


Photo by C. A. Fuller

IN THE VICINITY OF BROCKTON, MASSACHUSETTS

TORN FROM ITS MOORINGS, THIS BOAT WAS CARRIED AGAINST THE TREES BY WIND AND WAVE.

sity before leaving the tropics. Nevertheless, it is necessary to go back more than 100 years to find a hurricane in New England which closely approaches the storm of last September in destructive power.

II

The history of hurricanes in New England reveals some of the advances that have been made in detecting cyclones in their early stages of development and in following their movements from day to day. Perhaps the first of these visitations, of which there is any record, was the gale of September, 1635. Although this storm undoubtedly was of tropical origin and of great intensity, the only noteworthy result was widespread destruction of trees, there being then but few settlers.

No suspicion could have been in the minds of the scientists of that day that the hurricane is a sort of great whirlwind about a center of low atmospheric pressure, for the barometer was not invented until 1643 and hurricanes were not treated as whirlwinds until about 1650. Nearly two centuries passed before their nature was satisfactorily demonstrated.

Severe hurricanes visited New England in 1788 and 1815. The latter, known as the "Great September Gale," was probably equal in destructive power to the hurricane of September, 1938. Newspaper accounts of this storm were preserved, and were published in 1842, and from them the path of the storm can be accurately determined from the West Indies to the New England coast.

At the time of the September hurricane of 1815, Oliver Wendell Holmes was 6 years of age. His poem, "The September Gale," refers to this hurricane; the following is an excerpt:

> It chanced to be our washing-day,
>   And all our things were drying;

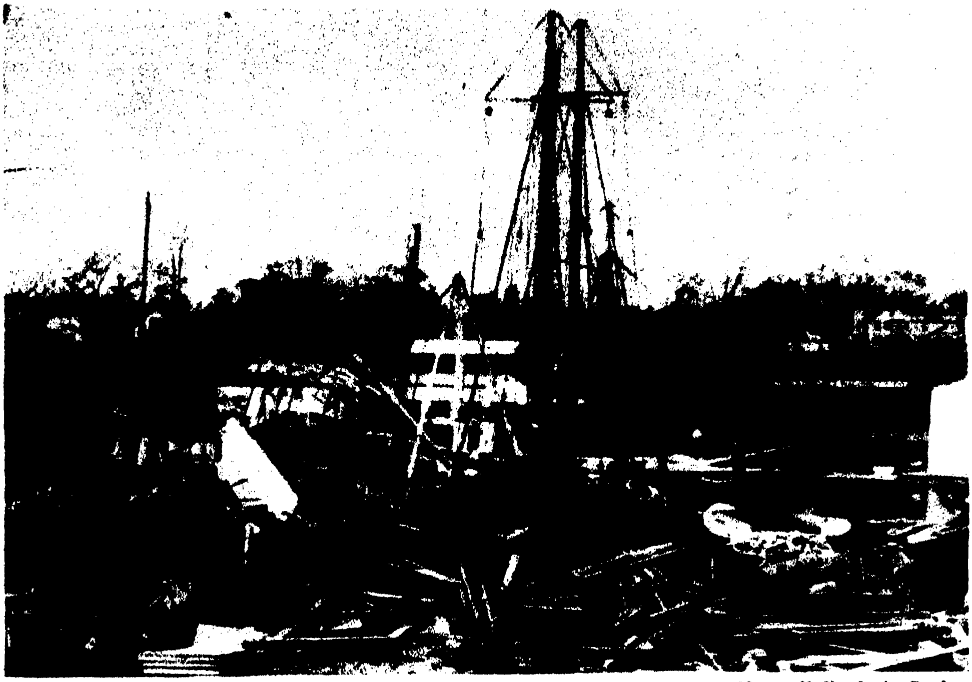


Photo by Maxwell Frederic Coplan

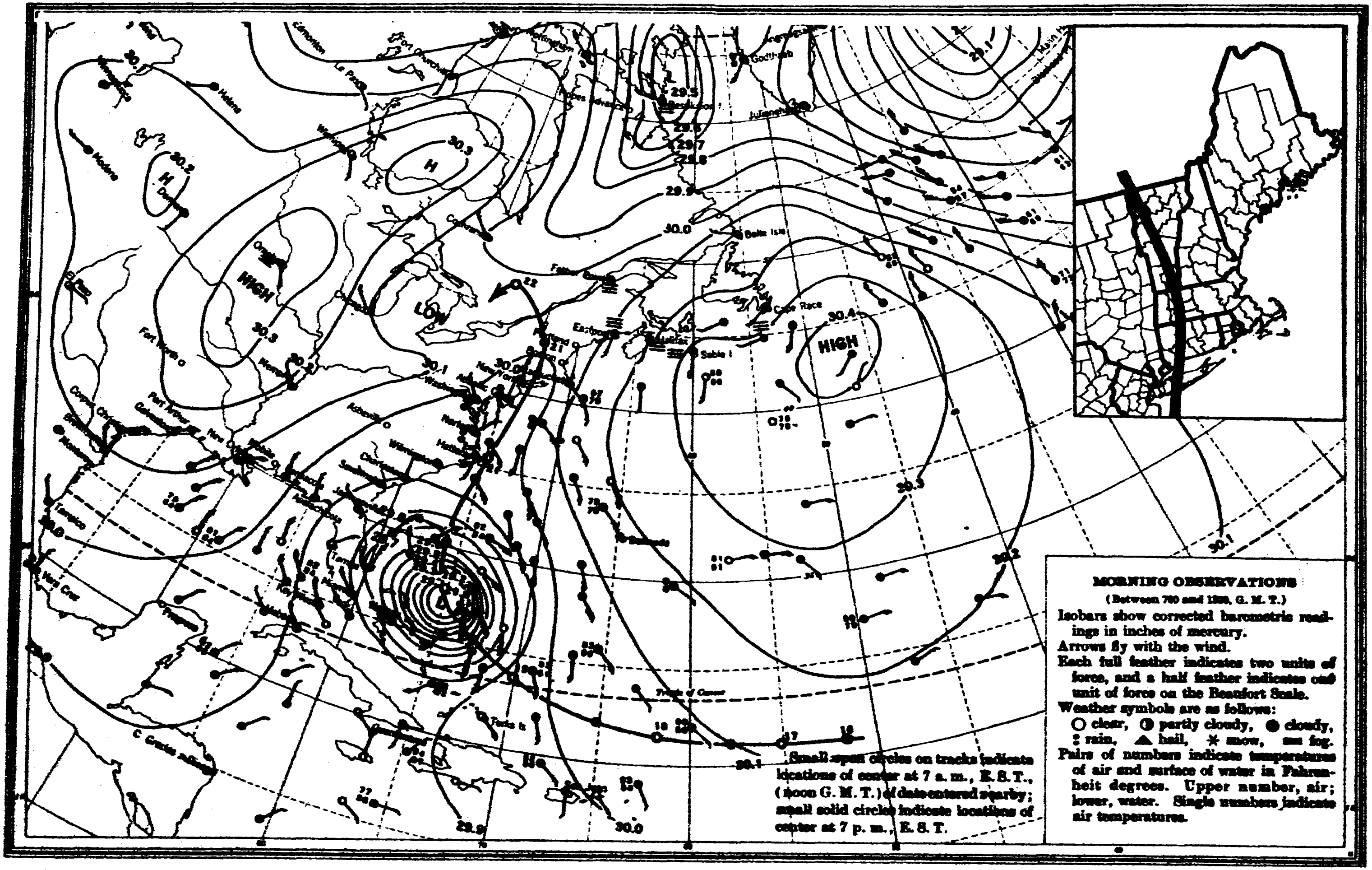
HAVOC WROUGHT TO BOATS ON THE EASTERN SHORE OF MASSACHUSETTS.

The storm came roaring through the lines;
And set them all a flying;
I saw the skirts and petticoats
Go riding off like witches;
I lost, ah! bitterly I wept,—
I lost my Sunday breeches!

The course of another September hurricane, in the year 1821, was very similar to that of the recent storm. It crossed Long Island, moving northward, its center passing to the westward of New Haven. In traveling over the devastated area, a saddler by the name of William C. Redfield (first president of the American Association for the Advancement of Science, and grandfather of the late William Cox Redfield, Secretary of Commerce in Wilson's administration) noticed the direction in which the fallen trees were lying and concluded that the storm was a great whirlwind. However, he did not publish his ideas until 1831, when Professor Olmstead, of Yale University, induced him to write an article for the *Journal of Science and Arts.*

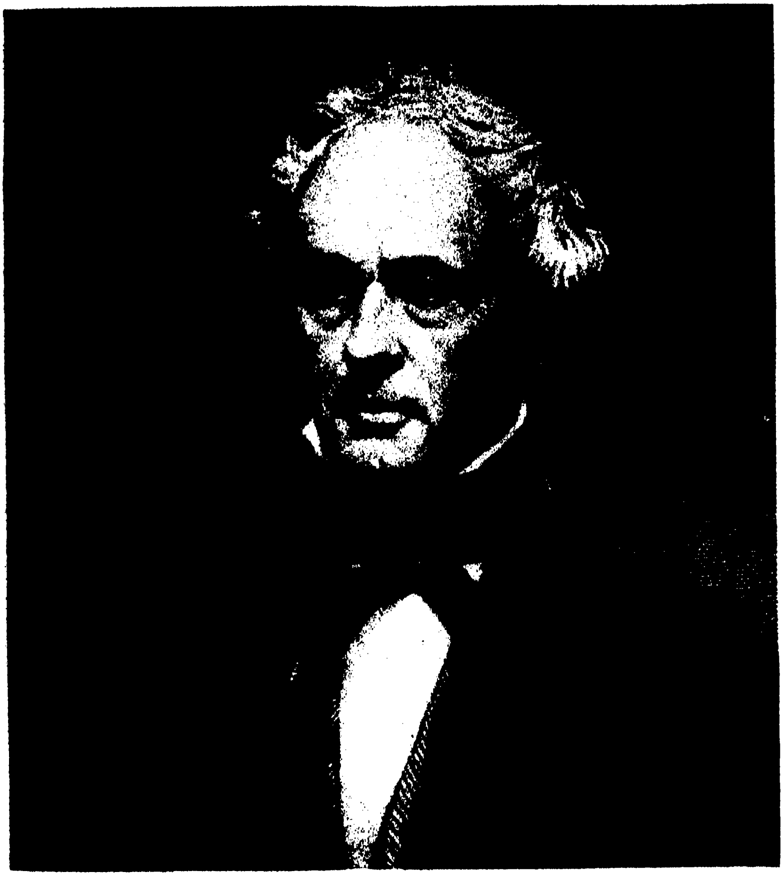
Under the stimulus of Redfield's discovery, tropical cyclones of the West Indies were studied, from the data available in the logs of sailing ships, and the paths of many of them were charted during the following quarter of a century.

The next severe hurricane in New England occurred in September, 1869. It was destructive over a path about 60 miles wide. However, there was no warning of its approach, as the national weather service was not established until 1870. The first cautionary warning of a hurricane approaching New England was issued in 1873. This hurricane was traced from the vicinity of the Cape Verde Islands westward across the Atlantic. Recurving between Bermuda and Hatteras, the storm took a northerly course and crossed the coast line of Nova Scotia, where it was very destructive. More than 1,200 vessels were lost. As the hurricane approached the Atlantic coast, cautionary warnings were



WEATHER MAP OF NORTH ATLANTIC OCEAN

FOR SEPTEMBER 20, AND THE TRACK OF THE HURRICANE FROM SEPTEMBER 16–22. INSET: PATH OF THE CENTER OF THE HURRICANE THROUGH



WILLIAM C. REDFIELD
FIRST TO DISCOVER THE WHIRLWIND CHARACTER OF THE HURRICANE. REDFIELD WAS ALSO THE FIRST PRESIDENT OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

hoisted at Cape May, N. J., New York, N. Y., and New London, Conn.

With the advent of radio communication, it became possible to follow a hurricane in its development and movement over the ocean and to give more accurate notices of its approach. There have been noteworthy achievements in the warning service, which include international cooperation, the voluntary assistance of seamen of all nationalities and precise coordination of collecting, mapping and broadcasting the information.

III

The first charted position of the hurricane of September, 1938, was at 21° north, 53° west, late on the 16th. Observations on the morning map of September 13 gave some evidence of cyclonic circulation near 19° north, 37° west, hence the storm probably originated near or south of the Cape Verde Islands. Many hurricanes of August and September have been traced to that region, but owing to the small number of ships over the vast ocean area between the Cape Verdes and the West Indies it is impossible to establish definite tracks for many that appear to have originated there. Positions far to the eastward have been determined after reports arrived by mail from meteorological stations on the Cape Verde

Photo by C. A. Fuller

TREES AND POLES UPROOTED BY THE HURRICANE NEAR BROCKTON, MASSACHUSETTS.

Islands or from steamers in the neighborhood.

Over waters near the Atlantic coast it is usually possible to plot the observations taken by ships in a hurricane with a delay of only about one hour in transmission by radio to the shore station and by telegraph to the Weather Bureau Office. Occasionally a ship is in a position to send a radio report which enables the meteorologist to determine the approximate location of the center of a

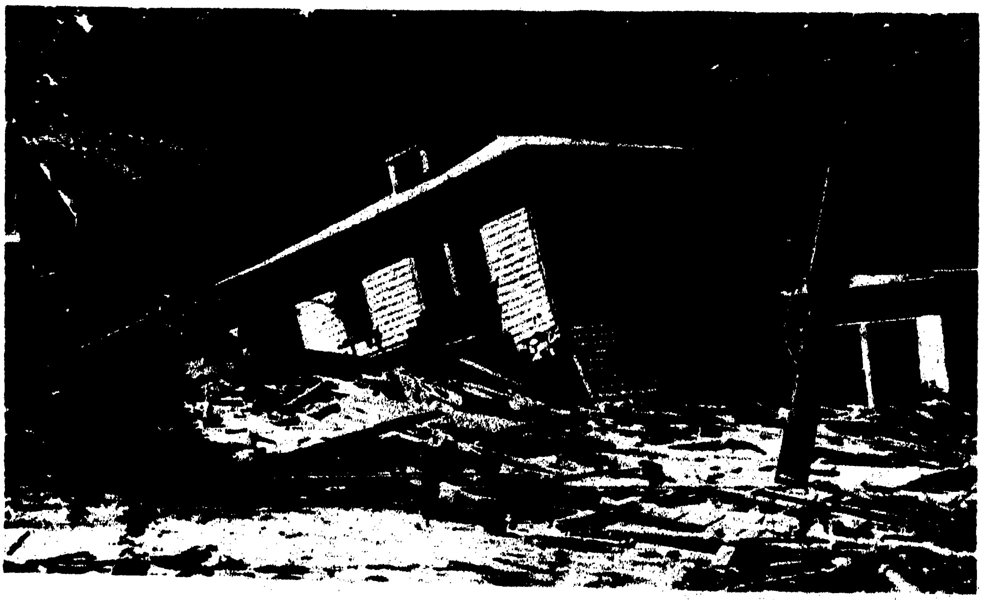


Photo by C. A. Fuller

A BUILDING IN THE VICINITY OF BROCKTON DESTROYED BY THE FORCE OF THE WIND.

hurricane far to the eastward of the West Indies within an hour or two after the observation is taken on shipboard. The record in that respect was the report of a hurricane from a ship at 17° 30′ north, 41° 18′ west, on September 28, 1936. In another instance, nearly as far to the eastward, a hurricane was located definitely by a radio report from 17° north, 48° 15′ west, on September 10, 1928.

Usually the movement of hurricanes far out in the Atlantic between the Cape Verdes and the West Indies is toward the west-northwest or west by north in early stages, but the majority recurve to the northwest, north or northeast before reaching the West Indies; a fraction of them continue on a westerly course until they reach the West Indies or the South Atlantic States or recurve to higher latitudes while traversing the waters between the Bahamas and Bermuda. A few of them have been of large diameter and great intensity on reaching the longitude of Puerto Rico. In recent years there have been some notable examples, in particular the hurricane of September, 1936, which was centered to the southwest of Bermuda on the morning of the 16th with strong winds (30 miles or more per hour) over an area with a diameter of nearly 1,000 miles. It crossed extreme eastern North Carolina but recurved sharply to the northeast with its center at sea a short distance from Nantucket. When the hurricane of 1938 passed between Bermuda and the Bahamas, the area of strong winds (30 miles or more per hour) was about 500 miles in diameter.

Photo by Maxwell Frederic Coplan

FRONT WALL OF HOUSE TRANSPORTED BY THE WIND TO A NEW LOCATION ON THE HIGHWAY.

The height of the barometer at the center of the recent hurricane was probably about 28 inches, or slightly lower during most of its course at sea. This is about the average for intense hurricanes of large diameter. Much lower readings have been recorded, however, the world's lowest being 26.19 inches in a typhoon east of the Philippines. In the United States the record is 26.35 inches on the Florida Keys in September, 1935.

On recurving to the northeastward and moving to higher latitudes, West

Indian hurricanes usually have a more rapid progressive motion (20 to 30 miles an hour) than they do in the tropics, where it averages about 12 miles an hour. Nevertheless, the recent hurricane was abnormal in that respect. In 12 hours it moved from a position off Hatteras to southern Vermont and New Hampshire. Over this part of its course its rate of progress was about 50 miles an hour.

On the right side, looking forward along the line of progress, the winds of the hurricane are directed more or less along the line of progression, so that their velocity in this portion of the storm is a combination of the two motions. On the left side, the forward movement is subtracted, more or less, from the wind system of the hurricane. Because of its extraordinarily rapid movement toward the north, the recent New England hurricane had destructive winds far to the eastward of its center, 100 miles or more, while there was relatively little damage to property on the west side.

Wind velocities were high; 82 miles an hour at Block Island, R. I., 87 at Providence, R. I., and 121 at Blue Hill, Milton, Mass., near Boston. These were sustained winds, measured for periods of five minutes; velocities for shorter intervals were much higher, as evidenced by measurements ranging from 173 to 183 at Blue Hill Observatory. Higher velocities have been recorded in hurricanes, notably five-minute velocities reaching 150 miles an hour at San Juan, P. R., in September, 1928. In many instances the wind-measuring instruments have been wrecked or the supporting structures have been thrown down prior to the full force of the storm, hence there is only fragmentary information as to the maximum velocities of hurricane winds.

Ordinarily, the tide on the coast near the hurricane center and to the right of it is considerably above normal as the storm moves inland. In some instances it reaches the proportions of a "tidal wave" or "storm wave" which is disastrous to life and property. On the coasts of India and China the loss of human life has been placed at 50,000 or more in a single storm. Exceptionally large losses of life were reported at Backergunge, India, in 1876 as the result of a tropical cyclone and storm wave, estimated at 200,000, and at Haifong, China, in 1881, estimated at 300,000.

In the United States, the greatest disasters of this source were in the Galveston hurricane of 1900 with loss of life reported to be approximately 6,000 and in the Florida hurricane of 1928 with nearly 2,000. In the recent hurricane in New England, the loss was about 600.

The areas of Long Island and New England, over which the recent hurricane moved, are much more densely populated than tropical and subtropical regions subject to such storms, except parts of India, China and Japan, and property values per capita are very much higher. Conservative estimates of the property damage on Long Island and in New England place the total between two hundred and fifty and three hundred and thirty million dollars. Indeed, there is little doubt that the value of property destroyed by wind and water attending the New England hurricane of last September was greater than that recorded in any other tropical cyclone in the world's history.

FAR AWAY AND LONG AGO

By EDWARD W. BERRY
PROVOST, THE JOHNS HOPKINS UNIVERSITY

I HAVE borrowed the title from Hudson's delightful recollections of his boyhood life on the illimitable acres of a Pampean Estancia because it is so appropriate a one under which to describe something of the life in Patagonia quite as far away and almost infinitely longer ago in which I have had a small part, even though that part was in the nature of what may be called retrospective prophecy.

A long experience has convinced me that geography is not one of the native accomplishments of our great republic. Perhaps its very size works against this, for it is easy to imagine that the educated class at least in a half-pint country would have a better knowledge of the rest of the world. At any rate my friends can never understand why I froze under the equator, why I did not burn wood in the Bolivian Andes, or why I much prefer the climate anywhere on the perimeters of the Caribbean to that of Baltimore.

I have been trying for over a score of years as opportunities offered to find out something of the floral history of South America. Of late years through the kindness of former students and friends and officials of surveys there has been no lack of material. Quite the most extensive collection was sent me a few years ago by the Argentina Survey through the interest of one of the younger members of its staff—Señor José Ramon Guiñazú. The results of this study were published last July,[1] and the editor has asked me to prepare a sort of abstract of this work for the readers of THE SCIENTIFIC MONTHLY.

[1] Geological Society of America Special Pub. No. 12.

Patagonia is the name of a somewhat vague region which has no political reality and which you will not find on a modern map. Formerly it was used for the antipodean part of South America shared by the republics of Argentina and Chile. As used in the present connection it comprises the three territories of Rio Negro, Chubut and Santa Cruz, extending from the crest of the Andes to the Atlantic Ocean and from about 40° South Latitude to the Straits of Magellan. Although it tapers off toward the Southern Cross and does not look very big on ordinary small-scale maps its area is greater than any European country except Russia.

The climate is about as bad as it is possible to imagine. There have been many descriptions of the inhospitable character of the treeless wastes and the depressing effect of the constant winds. Darwin writes of it in a letter to Henslow in 1832, "I had hoped for the credit of Dame Nature, that no such as this existed."

In his Journal during the ascent of the Rio Santa Cruz we find him writing: "The complete similarity throughout Patagonia is one of its most striking characters. The level plains of arid shingle support the same stunted and dwarf plants; and in the valleys the same thorn-bearing bushes grow. Everywhere we see the same birds and insects. Even the very banks of the river and the clear streamlets which entered it were scarcely enlivened by a brighter tint of green. The curse of sterility is on the land, and the water, flowing over a bed of pebbles, partakes of the same curse."

To be sure this was the reaction of a

homesick lad, and the country is not as bad as it is painted—some people even grow to be fond of it, although I have never had the good fortune to meet such a one. However, like the human derelict who asks for alms and assures you that he has seen better days, so it is with Patagonia in the long ago. If we look beneath the surface of the barren ash beds or examine the barrancas, there comes to light the manifold evidence of a glorious past—not simply the evidence of a single golden age, but of a long succession of great eras during which Patagonia was the home of a greater variety of strange beasts than any other region on the globe, either past or present. There were great beasts that looked like elephants or rhinoceroses that were not elephants or rhinoceroses. Even the familiar evolution of the horse was paralleled in quite an unrelated stock of mammals so that the clerical story of how Noah named the various animals would work out very badly in Patagonia. The story goes that the explanation of the naming of the elephant, the lion and the tiger was exceedingly simple. Noah merely christened them thus because they looked like an elephant or a lion or a tiger.

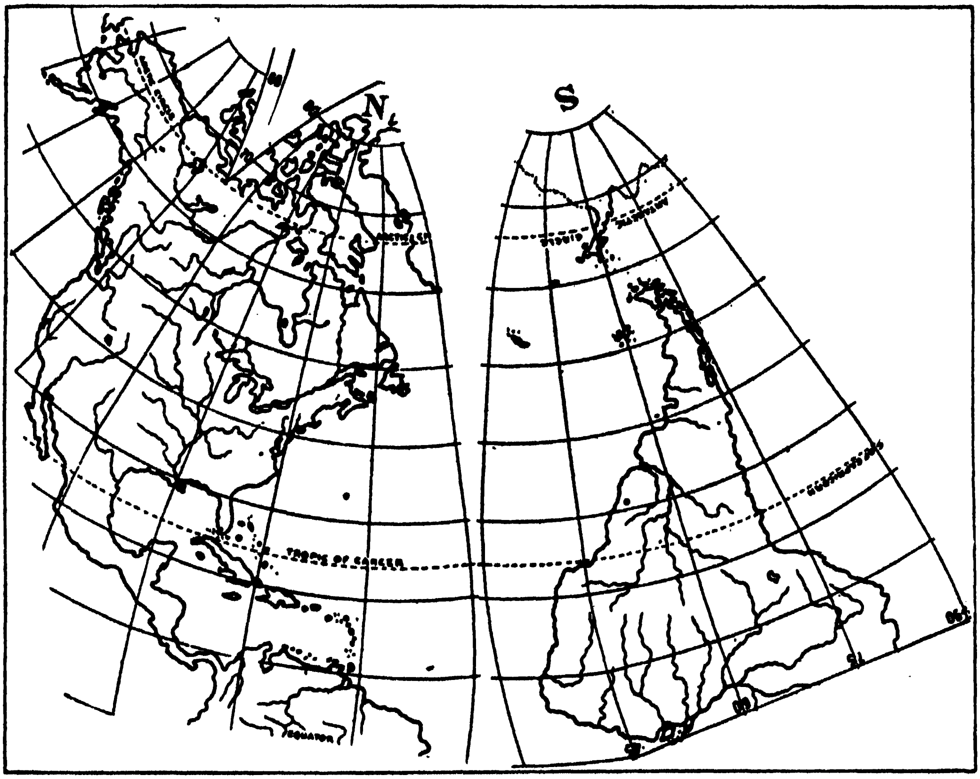
If this method had been utilized in the naming of the fossil fauna of Patagonia, Noah would have been obliged to call the Pyrotherium an elephant, the Astrapothere a hippopotamus, the Protothere a horse, some of the strange marsupials lions or tigers, and the Toxodont a rhinoceros. At any rate, as Scott well says, the Tertiary mammals of Patagonia are bewildering as if they belonged on another planet.

Naturally this maze of herbivorous animals which supported the host of carnivorous marsupials which preyed on them required food, but until a few years ago nothing was known of the vegetation of Patagonia in Tertiary times and the vertebrate paleontologists were inclined to paint a picture of treeless grassy plains, which is somewhat overemphasized and does not agree with the subsequent discoveries of the fossil flora.

In general it may be said, at least in so far as the angiosperms or flowering plants are concerned, that in the late Cretaceous, those of Patagonia were sufficiently like those long known from the northern hemisphere to class them as cosmopolitan types which had not been cut off by geographical obstacles from the common reservoir which was the region of dispersal of Upper Cretaceous floras. Some authorities think this center of radiation was in the Arctic region, others locate it in central Asia and still others think that it was in tropical uplands. The evidence on which these opinions are based is neither too clear nor at all conclusive.

Following the late Upper Cretaceous floras in Patagonia is a second stage, the age of which I have called Paleocene. This is a broad-leafed dicotyledonous flora indicative of rather mild climatic conditions and which appears to stand in an ancestral relationship to what I have called the Eogene flora. This last is a rather wide-spread flora, perhaps not everywhere of exactly the same age, dominated by small-leafed trees of which a great variety of beeches are the dominant element. This has long been known from the Straits of Magellan region, from Seymour Island on the coast of Antarctica and from various localities in Patagonia, in Chubut and Rio Negro territories, or northward to about latitude 40° S. This is a temperate flora, indicating a somewhat harsher climate than the Paleocene flora which preceded it, or what I have called the lower Miocene flora which succeeded it.

The last, which is the most abundant and varied of all, comes from a number of localities in all three of the Patagonian territories from Rio Negro on the north to Santa Cruz on the south, from



CORRESPONDING LATITUDES IN NORTH AND SOUTH AMERICA

the Rio Pichileufu about 30 miles east of Lago Nahuel Huapi (Long. 71° W) on the west to the Valcheta basin (Long. 66° W) on the east. Thus it extends through 5 degrees of longitude and through 7 degrees of latitude, and hence it overlaps the Eogene floras southward some 10 degrees.

This assemblage is most prolifically represented at the Rio Pichileufu locality. It comprised over 125 different arborescent forms: a grass related to one of the modern Pampas grasses (Chloris), three striking kinds of ferns, one of which is a tree fern, and a very abundant cycad. After some restricted comments on the more spectacular plants I will pass to some general conclusions.

One of the more abundant finds was a well-marked species of Ginkgo. The fascinating history of this genus has often been discussed both popularly and scientifically. It is commonly considered Asiatic; Darwin called it a living fossil because its sole surviving species was preserved from extinction in the temple gardens of eastern Asia, which may have been the only region where it survived to be contemporaneous with the human race, although, as a matter of fact, no wild species have ever been authentically reported. Ginkgo is a very ancient type which had attained a wide distribution by Jurassic time, at the latest. The discovery of a Tertiary species in Patagonia completes the list of the continents on which Ginkgo was a member of the Tertiary flora, and on many of these—for example, Europe—it was present as late as the Pliocene.

Another interesting find was many twigs and cone scales of a species of Araucaria—the Chilean or Norfolk Island pine or monkeypuzzle of modern bota-

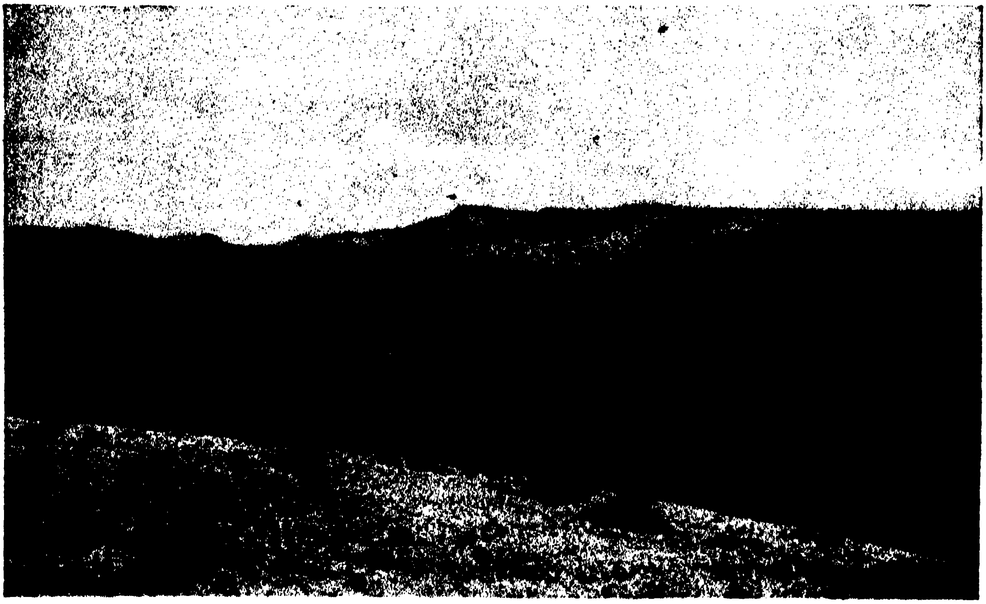


Photo by José Ramon Guiñazú

THE FOSSIL PLANT LOCALITY ON THE RIO PICHILEUFU (AT THE RIGHT). IN THE FOREGROUND IS MORAINIC MATERIAL.

nists. In existing floras this genus is confined to southern Brazil, a relatively small area in southern Chile, and the Australian region. If nothing were known of its geologic history this modern distribution would afford a strong argument for an Antarctic or at least antipodean center of radiation. But Araucaria is a very ancient type and attained a nearly world-wide range during the Mesozoic era. It was exceedingly common in North America as well as on other continents during Upper Cretaceous time, and its present-day occurrences are readily understood as the surviving representatives of a northern center of radiation and require for their explanation no shifting of continents nor hypothetical land bridges in southern latitudes. Araucaria has been found in Argentina in the Rhaetic deposits and was exceedingly common in that region during the Jurassic, as indeed it was in the earlier Tertiary.

I know of no better illustration than Araucaria for showing the futility of discussions of the origin and distribution of plants by botanists familiar with the plants of only one geological period and that the Recent. A generation ago the plant geographers looking at the existing Araucarias in South America and the Australian region were forced to conclude that it either originated in Antarctica and spread into temperate South America and to New Zealand, Norfolk Island and Australia, or that it originated in one or the other of these places and spread to the others over a trans-Pacific land bridge. The present fossil Araucaria still further illustrates this thesis. Patagonia to-day is practically treeless, whereas the inter-Andean valleys and the south of Chile are covered with dense forests. One of the canons of plant geographers has been that a large number of Argentine plants were introduced from the Chilean region. We now know that a large number of trees, whose descendants have only survived in the wet Chilean region, were present in Patagonia for several mil-

lennia and disappeared from that region in geologically very modern times after the Andes had reared their bulk across the moisture-laden "roaring forties" and thus desiccated Patagonia.

Eucryphia is another genus frequently brought forward as evidence for an Antarctic continent with connections to Australia and Patagonia, or for a trans-Pacific land bridge. Its two existing species, one in Chile and the other in Australia and Tasmania, are nearly 160° apart and are believed by systematic botanists to be closely related. A direct land connection between the two involves a terrific strain on the imagination, and it is difficult to explain why, if there had been such a connection, New Zealand failed to receive its quota. Unfortunately, no fossil species are known except the one from Patagonia that is described in the recent report. The foliage of the two existing species is quite unlike, and it is doubtful whether even if the genus were present in northern fossil floras it would have been recognized, so that I prefer to withhold judgment.

All in all there are 99 genera in 57 families and 28 orders in this early Miocene flora. It is therefore the most extensive known Tertiary flora from South America, being approached only by the flora of the same age from the Arauco-Concepcion coal measures in southern Chile, and that from the Island of Trinidad at the other end of the Andean axis.

Two new genera are recognized Pouterlabatia in the Sapotaceae and Polioexolobus in the Asclepiadaceae. New species are described in the following 15 existing genera which have not hitherto been recognized in the fossil record: Adenocalymma, Azara, Diatenopteryx, Embothrium, Eucryphia, Landolphia, Mascagnia, Myrceugenia, Notaphoebe, Nyctaginites, Remijia, Salacia, Styloceras, Tabebuia and Villaresia.

The largest single genus is Myrcia, with six species and varieties. Next

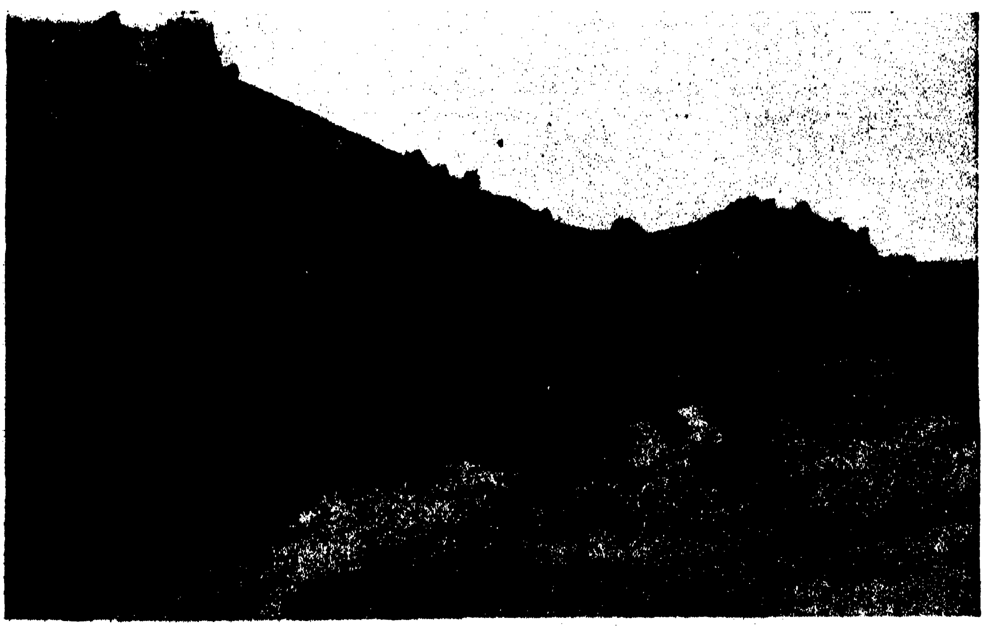


Photo by José Ramon Guiñazú

RIGHT BANK OF RIO PICHILEUFU VALLEY

BELOW THE FOSSIL PLANT LOCALITY, SHOWING REDDISH RHYOLITIC TUFFS INTERBEDDED WITH LIGHT SANTA CRUZ TUFFS.

come Cupania, with five species; Cassia, with four species; and Sterculia, with three species.

The largest family is the Sapindaceae, with 13 species, followed by the Lauraceae, with 10 species. The Myrtaceae and Rubiaceae have each 8 species; the Anacardiaceae 6 species; the Sterculiceae and Flacourtiaceae 5 species each; the Caesalpiniaceae, Meliaceae, Celastraceae and Apocynaceae 4 species each, and the Proteaceae, Malpighiaceae, Sapotaceae and Bignoniaceae 3 species each.

The cycads, those strange relics of Mesozoic times, are abundantly represented by a species of Zamia, whose living representatives have retreated many degrees to the north. Beside Araucaria, already mentioned, the conifers are represented by Fitzroya, named after Captain FitzRoy, of the *Beagle*, Libocedrus and Podocarpus.

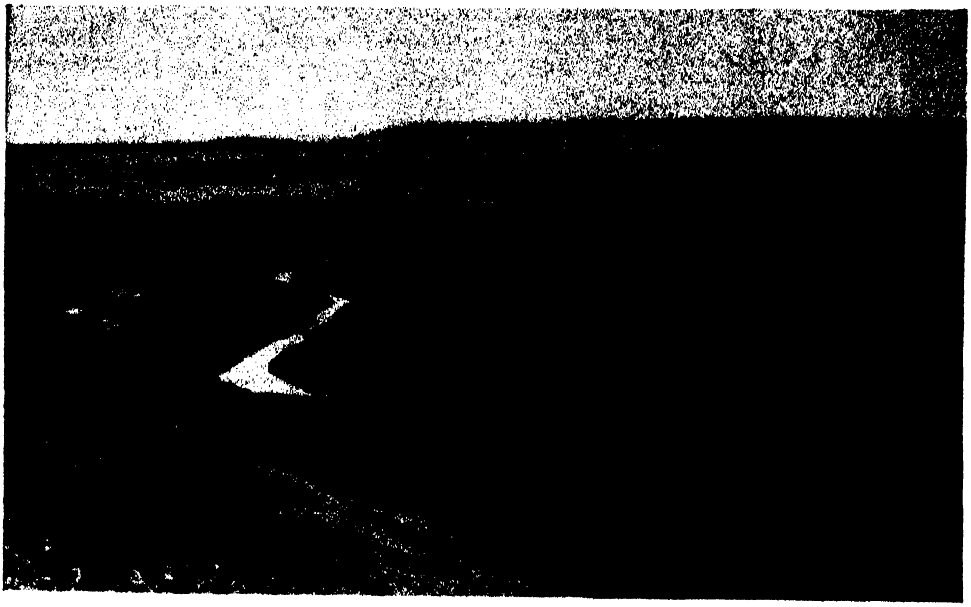
Practically nothing is known of the history of the genus Fitzroya. There is an existing Chilean species and in Tasmania a closely related form which is sometimes made the type of a second monotypic genus. In view of the antiquity of the Coniferales I do not imagine that any student would predicate any sort of a direct land connection between Chile and Tasmania as the explanation of the present-day range of Fitzroya.

The two fossil species of Podocarpus at Rio Pichileufu belong to a genus which, in the modern flora, is as characteristic of the Southern Hemisphere as the pines are of the northern. Its geologic history has never been elucidated, although it appears (as Nageiopsis) in the Mesozoic floras of the Northern Hemisphere and is certainly identified in the Tertiary of Europe. Its presence in South America in all probability dates from the Upper Cretaceous or earlier, and its modern range in South America was undoubtedly conditioned by the last great epeirogenic movement of the Andean region.

There are six genera present in the Rio Pichileufu flora which in the existing flora occur both in South America and in one or several of the Pacific lands far to the west. Thus Embothrium and Drimys are South American and Australian; Laurelia is confined to Chile and New Zealand; and Coprosma is South American and wide-ranging in the Pacific islands to New Zealand and Australia. If the geologic record were more completely known, these facts of present-day distribution might be explained. Both Drimys and Lomatia are represented in the fossil floras of the Northern Hemisphere and appear to have been southern immigrants from some northern center of dispersal. The others may have radiated from some antipodean center, but the evidence is insufficient to establish such a supposition.

About 71 per cent. of the Rio Pichileufu species are new to science, and only 38, or about 29 per cent., have been found at any other localities. Nearly all the species represented elsewhere are found in beds supposed to occur at similar or identical horizons in the Concepcion-Arauco coal measures of Chile, or in Chubut and Santa Cruz Territories in Argentina. The only species that has been found in any other region is *Cassia longifolia*, which has been reported from Ecuador, Venezuela and Trinidad.

One of the most striking features of this flora is its typically American character. Of the genera represented 14 are confined to South America. These are Polylepis, Leptolobium, Icica, Styloceras, Schinus, Schinopsis, Astronium, Villaresia, Diatenopteryx, Azara, Ampelodaphne, Myrceugenia, Adenocalymma, Remijia. There are 26 additional genera which are confined to the Western Hemisphere. These are Zamia, Momisia, Coccoloba, Inga, Cedrela, Tetrapteris, Banisteria, Mascognia, Omphalea, Cupania, Matayba, Banara, Nectandra, Oreodaphne, Acrodiclidium, Eriodaphne (if this is properly segregated



THE RIO TURBIO
VIEWS ILLUSTRATING THE BARRENNESS OF THE PATAGONIAN TERRANE.

from Notaphoebe), Goeppertia, Psidium, Oreopanax, Bumelia, Allamanda, Echites, Tabebuia, Hoffmannia, Coussarea and Rondeletia. It will be noted that these 26 genera, although not confined to South America, are nearly all equatorial American—that is, they are essentially South American genera which have extended their range through the Antilles, or into Central America, or have even reached Florida (Zamia). The genera above enumerated, which may properly be considered essentially South American, number 40 out of the total of 97 known genera—that is, slightly more than 41 per cent.

In addition to this exclusively American element there are 29 genera represented which may be classified roughly as cosmopolitan, or at least as very wide-ranging in modern floras of the warmer regions of the earth, and many of which may as properly be considered American as of any other nativity. Some of these are very large and old genera with a rather continuous distribution. Others are relatively small, such as Cochlospermum or Cephalanthus, with a discontinuous distribution, and no two have precisely the same geologic history. These genera are Goniopteris, Asplenium, Dicksonia, Myrica, Ficus, Anona, Berberis, Hydrangea, Cassia, Dalbergia, Fagara, Salacia, Sapindus, Allophylus, Cissus, Triumfetta, Sterculia, Buettneria, Tetracera, Ouratea, Casearia, Cochlospermum, Myrcia, Ardisia, Styrax, Symplocos, Plumiera, Strychnos and Cephalanthus.

The genera already named account for over 71 per cent. of those represented in the Rio Pichileufu flora.

This leaves 28 genera, or less than one third of the total number (between 28 and 29 per cent.), whose origin may have been different from that of the others or which may have reached the region by a different route. Among these the only one that is often, though wrongly, considered to be Asiatic is the genus Ginkgo.

Besides the new genera and the form genera there remain 11 genera, all

dicotyledons, whose present range is worthy of comment. The lauraceous genus Phoebe, as delimited by systematists, is found in South America and the East Indies and has an outlying species in the Canary Islands. It may be remarked that this apparent wide range is probably to be explained as a taxonomic faux pas and requires no other explanation.

It would be expected that the Rio Pichileufu flora would show some similarity with the African flora if there were any basis for the Wegener and other hypotheses of continental drift. As I have frequently stated, I can see no evidence for these speculations in any of the Tertiary floras of South America. These floras are quite as typically South American as the present floras of that continent. In addition to the wide-ranging genera represented at Rio Pichileufu, whose existing relatives include both South America and Africa in their circumequatorial range, there are but four genera in this fossil flora whose existing relatives are confined to South America and Africa. These are Erythroxylon, Trichilia, Paullinia and Landolphia.

The genera Erythroxylon, Trichilia and Paullinia are all large genera which in existing floras, are mostly American but are sparingly represented in the African Tropics—Paullinia by a single species, if the identification can be relied upon. Paullinia also has a single species in the Sandwich Islands. One wonders whether this is a problem in plant geography or more likely a problem in systematic botany. There are two schools of plant geography—an older school which considers that the region where a group is most abundant is its original home, and a more modern school, probably best exemplified by the late W. D. Matthew, a vertebrate paleontologist, who held that the region of modern abundance is farthest removed from the original source. Neither view is correct to the exclusion of the other. Certainly the abundant and largely South American Sapindaceae, to which the genus Paullinia belongs, exemplify the older view.

The fourth genus, Landolphia, is relatively small and largely West African and is sparingly represented in South America, mostly in Brazil.

An extended analysis of the fossil flora and of the habits and habitat of those existing plants which are most similar to the fossil ones seems to indicate more genial conditions in Patagonia at the beginning of Miocene times than obtained in the earlier Tertiary. For example, no traces have been discovered of the numerous beeches so abundant in the Eogene flora. Not only was the climate warmer, it was also wetter. Among the genera of dicotyledons, about two thirds are commonly considered tropical and one third temperate. There is slight precision in the terms, and large genera are apt to occur under a variety of conditions.

There are several genera that survive in the temperate rain-forest region of southern Chile, such as Araucaria, Fitzroya, Laurelia, Libocedrus, Lomatia, Myrcia and Podocarpus, but in this Miocene flora there is no trace of the Fagaceae, which are now so prominent an element in that flora, as indeed they were in Eogene time.

Some of these genera may also be called Andean, in looking backward from the present, but the number is not large. They are exemplified by the spread northward at a later date, when the main Andean uplift occurred, of Polylepis, with its 15 Andean species reaching altitudes of 14,000 or 15,000 feet and extending to Colombia; by Styloceras, now found from Colombia to Bolivia and to altitudes of 12,000 feet; by *Lomatia obliqua*, which reaches Ecuador; and by *Podocarpus andina*, *Embothrium grandi-*

florum and *Schinus molle* which I have seen in the Peruvian Andes and which may extend much farther north.

Fourteen genera are considered to have been lianas. Nearly half of the genera have fleshy fruits, 19 being drupes and 20 baccate. Genera with capsular fruits number 20, and genera with winged or pappus-bearing fruits or seeds are also 20 in number.

To find assemblages like the fossil flora requires us to go northward from 10 to 15 degrees to the Argentine Mesopotamia, Paraguay and southern Brazil. Stated another way, it means that at the beginning of Miocene times, because of an amelioration of conditions many genera of equatorial America, which has remained the richest and largest area of tropical forest in the world, were enabled to spread southward over what is now Patagonia, some of the elements getting southward as far as Latitude 51° South. Of course the Andean backbone of South America could not have been in existence at the time because the fossil flora is identical on both sides of this axis.

If the Miocene conditions are compared with the existing conditions, there are the greatest contrasts. It would take a book to describe the present-day physiography and climate of the region. The lava plateaus and base-levelled steppes at levels from 2,000 to 6,500 feet, as well as the flat emerged old seabottoms at lower levels all appear as Pampas on the maps, seemingly euphumistic to those who have seen the pampas of Buenos Aires. At any rate to the south the precipitation varies to-day from about 8 inches to almost nothing, and whatever it is the evaporation is greater than precipitation and the whole country is treeless, wind-swept and inhospitable, with a short growing season, as may be realized far better by looking at the accompanying illustrations than by lengthy comment. It is quite erroneous, however, to think of this region as an Antarctic one.

North America extends so much farther from the equatorial zone than South America, and the climate of Patagonia is so inhospitable that the fact that Glasgow, Leningrad, Oslo and

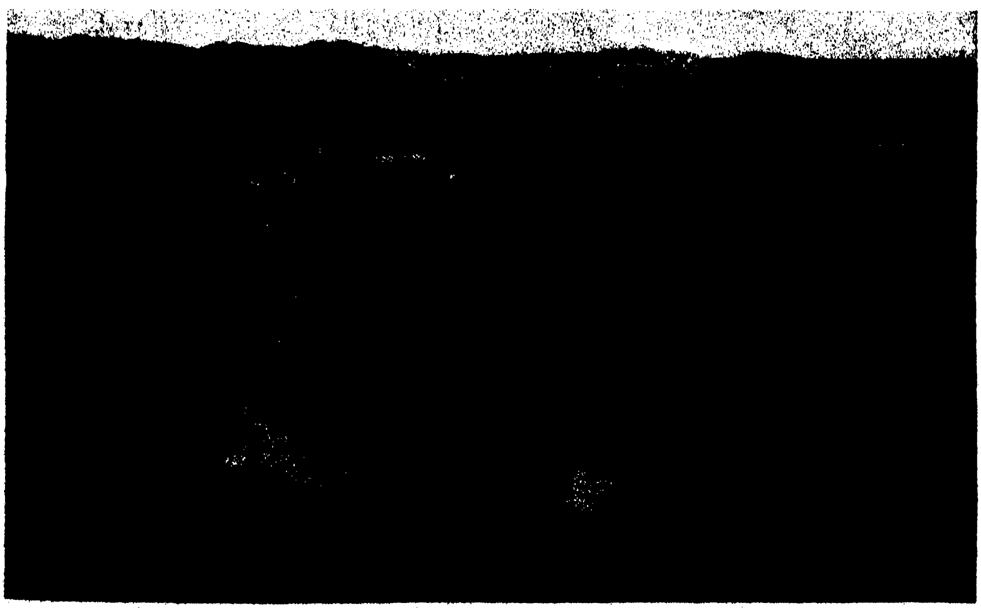


Photo by Bailey Willis

VIEW SHOWING ABUNDANCE OF PETRIFIED TREES IN VALCHETA BASIN IN NORTHEASTERN PATAGONIA.

Stockholm are farther north of the Equator than Cape Horn is south of it is likely to be forgotten. The fossil locality on the Rio Pichileufu is almost in exactly the same south latitude as Bridgeport, Connecticut, is in north latitude.

In the accompanying text figure I have placed equal-area projections of North and South America side by side in reversed positions to show the correspondence in north and south latitudes.

Structural geologists have found out that the everlasting hills are not nearly as permanent as they seemed to the psalmist, for destroying forces beat against the high mountains like calumnies against human eminence, and if the geological time scale is taken into account both states are equally transitory.

Mountains are not permanent global features any more than coast lines—both are subject to ceaseless change. The most that may be said for mountainous regions is that they tend to be rejuvenated again and again after being repeatedly worn down, so that if we might borrow a phrase from medicine, we might say that orogeny tends to become chronic for certain regions. Thus, the Andes, one of the world's greatest mountain chains, experienced their most extensive elevation in times geologically modern, and long subsequent to the early Miocene that I have been describing. How old are these Miocene floras? I have yet to meet any one who has not laid his hand on the altar in the Temple of Paleontology who, shown a fossil, does not ask first of all, "How old is it?" even as Scrooge, confronted with the spirit of Christmas past, wanted to know "How long past?" According to the latest and current fashion of estimating the age of the earth by the seemingly precise methods of atomic disintegration, the flora I have been describing should have flourished about 25 million years ago. Perhaps what seems so certain may seem just as silly a generation or two hence as Lord Kelvin's classical estimates based on the rate of cooling bodies and before man knew about radio-activity.

I can never forget in this and similar situations an issue of the *Philistine*, the magazine published by that somewhat ribald philosopher, Elbert Hubbard, who at the time of the American visit of Sir Robert Ball—the astronomer royal—published what purported to be the coat of arms of Sir Robert and with the following superscription, "Hi olds knowledge by the tail, and stands ready to snap hof it goddam ead hoff."

SOME PHILOSOPHICAL REFLECTIONS OF A BIOLOGIST

By Dr. R. E. COKER
PROFESSOR OF ZOOLOGY, UNIVERSITY OF NORTH CAROLINA

The Invasion of Philosophy

A certain consciousness of personal inadequacy in philosophic thought brings to mind an experience I once had in connection with a rabbit hunt on the Banks at Old Fort Macon near Beaufort, North Carolina. This isolated region, inhabited then by only one human family, that of the sergeant in charge of the fort, would each year become thickly populated with rabbits, which in autumn would be the object of a hunt, participated in by a considerable party who would descend upon the scene to combine raptorial, social and perhaps convivial activities in one grand thanksgiving half-holiday observance.

On one of these occasions, as I came out from the hotel in hunting togs, I was accosted by an old fisherman, who asked rather pointedly what I thought I was going to do. When told, he inquired in a tone of surprise and reproof if I did not know that the tide was on the ebb. I said yes, but what had that to do with hunting rabbits? "Don't you know," he said, "that you can't get rabbits when the tide is on the ebb, that they come out and feed only on the flood tide?" I said I had understood that some fish are addicted to feeding on the flood tide, but not terrestrial animals such as the rabbit. Feeding on the flood, my informer rejoined in a most positive tone, is universal among animals. It is, he maintained, a basic law of nature from which rabbits are no more exempt than pigfish or mullet. Then he added, sympathetically: "Ain't it strange that you have been to school and college, and I ain't never even been to school, and I know more about rabbits than you do?"

The immediate sequel to this incident was that we returned from the hunt with 35 rabbits! The application must be obvious. Isn't it strange that with those about us who have devoted years in college and university to the study of classical philosophy, a zoologist, who has never passed even the grammar grades in the subject, should presume to talk about philosophy? One may well anticipate with almost a feeling of awe the prospective bag of philosophic rabbits to which a disquisition such as this may be a prelude. The only sound defense, if there be any, for the present display of audacity is that there may be those who would be interested in one more answer to the question—how an everyday zoologist, if he gives any thought to the matter at all, attempts to orient himself in the field of synthetic thought.

It is, however, a fact that scientists of to-day, particularly those in the physical fields, are regularly looking across the international boundary line that formerly separated, if somewhat vaguely, the territory of science from that of philosophy. Indeed, this is far too conservative a statement. Some physical scientists not only cast their eyes across the line, but actually they step across in aggressive and solid ranks to demand, in the new territory, not merely spheres of influence but actual dominance over extensive areas of the fertile philosophic fields. Can it be improper, then, that there should be an occasional discussion of the philosophy of science from the standpoint of the oldest of the scientific

disciplines?[1] Need biology be immune against the modern "philosophization of science," in the words of Jasinowski?

Protoplasm and Thought

Applying ourselves now more directly to the stated topic, doubtless the first thought of a philosophic nature that must come to the mind of a biologist provided with an audience and the topic "Philosophy" is that he and his listeners constitute a gathering of masses of protoplasm, more or less shapely masses, each of which manifests itself with a high degree of specialization in different parts of each mass and with marked individuality in the wholes. The speaker has a protoplasmic base, and so has each listener. What the speaker thinks and what he says is an expression of the activities of some of the specialized bits of protoplasm that form a part of his total organization. As to the listeners, their interest or lack of interest, their acquiescence or criticism—all these are activities of specialized bits of protoplasm, activities that in a good physiological laboratory can be measured in terms of oxygen consumption. There seems to me to be no present escape from that conclusion, the implications of which may command our attention for a few moments.

It may be a stale quotation to the philosophers and to others, but an oft-quoted poem may serve a useful purpose in this connection:

> There was a young man who said God
> Must think it exceedingly odd
> That the sycamore tree
> Just ceases to be,
> When there's no one about in the quad.

[1] There may be those who would question a reference to Biology as the oldest of the sciences. The matter cannot be argued here, but there seems the best of reasons for believing that it was perhaps the first of the "disciplines" in which prehistoric knowledge was systematized and human welfare advanced through observation, experimentation, inference and generalization, with the generalizations sometimes quite incorrect, incomplete or even as doubtless are some of our current generalizations.

There was a reply to that which, unfortunately, I do not recall in its exact words, but it was in the nature of a poetical reply from the Almighty enjoining the young philosopher not to be concerned about what might happen to the sycamore tree under hypothetical conditions, because actually there was never a time when a Supreme Being was not "about in the quad."

This answer might conceivably give satisfaction to a theologian or a philosopher, but it gives none to a zoologist, and this without reference at all to his belief with respect to a Supreme Being. The zoologist feels entirely sure that the sycamore tree that he and his kind know can not be expected to exist for any being or person not provided with an eye with an eight-layered retina, an optic nerve and certain nerve cells in the brain, and all in good working order. As a matter of fact, the sycamore, as I know it, does not exist for one of my friends, who has certain deficiencies of the eye or of the brain: an important part of the tree, its bright golden autumn color, simply does not exist for him. When only this man is "about in the quad" the whole tree is not there. You could give any one of us a few drinks of a well-known fluid, and other essential qualities of the tree would be lost—the single trunk, the sharply defined twigs, etc. As a matter of fact, we do not ourselves, at best, see the tree completely—because our organs of vision are responsive only to the wave-lengths of light that fall within a limited range. Sever now the optic nerves and all the qualities of the tree, which we had been able to perceive through the eye, are lost, although others may persist. Assuming, as some one has suggested, fancifully but not altogether illogically, that the light waves could be slowed down, shortened and caused to impinge upon the ear, the sycamore would cease to be an image against the sky, but rather a clatter of sound or perhaps a piece of music. The thunderous crash of a tree in the forest

is, of course, non-existent without an auditory organ and its associated nerve tissue, and why not the color and the form of our tree without the vertebrate eye? Theoretically, with proper adjustments, the fall of the tree could be a flash of light rather than a crash. The reason we do not hear the lightning and see the thunder is possibly a mere matter of wave mechanics.

However it may be with sound, it should be well known to every one that we can translate pressure into light. One only has to press upon his eyeball to demonstrate the correctness of this statement. If we do not fool ourselves as to the actual existence of the stars or flares of light caused by pressure upon the eyeball, there is no more reason to fool ourselves as to the actual existence of the fall colors or the architectural characters of the tree *as we "see" them.* Something, yes, but not just those things.

This is not to say that without a vertebrate retina and cochlea there would be nothing in the place of the tree and the rustle of leaves. Indeed, if there were in the quad only a grasshopper with its compound visual organ, there would undoubtedly be something where we find a tree, but it would surely be something that we should not recognize as a sycamore tree. If now you or I should conceive of some other sort of eyes in the absence of any form of animal life, I have nothing to say about that except this: that the objects envisioned would not, *for any reason that we can see,* be what we know as a tree. Every bit of evidence that we have should convince us that there is not actually outside of the brain precisely such a thing *as the tree that is pictured on our brain cells.* Nor is there actually a brain cell such as we have seen in the laboratory except as the light waves coming from the preserved brain cell under observation with the microscope in the laboratory affect the retina of our eyes in such a way as to cause an alleged impulse to pass to the assumed cells in the cortex of the brain which in turn respond in such a way as to give us a picture that we know as the brain cell.

We are led to the broad generalization that all that we see and hear, all that we feel and think, all the knowledge and sensation we have are dependent upon the activity of the substance known as protoplasm as it is found in sense receptors, nerve fibers, brain cells, etc. Accepting this as a correct statement, and there seems to be no way to question it, we are led to the further and disconcerting conclusion that all we know about sense receptors, nerve fibers and brain cells or about protoplasm in any form is a result of the activity of protoplasm. We arrive at brain cells and protoplasm in just the same way that we arrive at the sycamore tree, and that is through the use of protoplasm. Protoplasm is itself, then, a protoplasmic product, in a subjective as well as in an objective sense.

Finiteness of Thought

Now, as I do not wish to seem to bog down in metaphysical subtleties, for which I am not personally adapted, I may epitomize what has been said in one brief statement, which is not a metaphysical but rather an eminently practical one; *viz.,* that all ideas are the fruits of protoplasm, and that protoplasm itself is an idea. Complete the syllogism, if you wish. What I would say now is that in our acquirement of knowledge and in all our intellectual activities we are obviously confined within a circle from which there is no escape. Whatever may be the condition of the physical universe, the universe of thought is certainly a finite one from the point of view of the biologist. It may be that the philosopher finds some way of stepping over the circumference of the circle that hems us in to soar out into a limitless space; but I can not resist the conviction

that he merely steps into the confines of another circle. If he can free the mind from protoplasm, which does not appear probable, can he free the mind from itself?

By way of parenthesis, let us note that there have been those who have conceived of the mind as something detachable from protoplasm. Certainly, however, all efforts to effect the detachment in any particular case have proven futile. Just recently a good North Carolinian living in another state undertook the age-old experiment of trying to retain his spiritual and mental faculties without meeting the demands of the protoplasmic base upon which they are thought to rest. It was no surprise to any one that his experiment failed after a long and painful period of trial. Should we laugh at a man who had the courage to submit his sincere, and to him well-bolstered, conviction to the crucial test? I do not think so; how much better it would have been, however, if he had known just a little biology! I do not know if it has occurred to others, apparently it did not occur to the experimenter in this case, that, with equal fidelity to his convictions, he could have made the experiment just as significant and conclusive within a period of five minutes and have saved himself and others the agony drawn out through weeks and months. While attempting to keep his body deprived of food, he overlooked entirely the fact that he was feeding it sixteen times every minute. If, besides shutting off the supplies of protein and carbohydrates, he had shut off the oxygen supply as well—that is to say, if he had tried to stop breathing—he could have learned within five minutes whether or not his higher faculties could survive without physical nourishment.

The conclusion we have reached up to this point may seem trite to the philosopher, but it has seemed worth while to show how the conception of a finite world of thought is inevitably arrived at by a consideration of the biological basis of man and of his thinking processes. "Seeing through a glass darkly" is a conservative statement.

There may be some who would say, but only thoughtlessly, I am sure, that the recognition of a limit to the possibilities of penetration into the mysteries of the nature of the world and man is an unhappy one. I see no basis whatever for discouragement or disillusionment in the idea of a finite intellectual world. How many of us are concerned or saddened by the fact that our physical bodies are unable to escape from the terrestrial sphere in which we live and where the longest possible journey in a direction straight ahead would eventually bring us back to the point from which we started? Even within a finite sphere there is ample room for all the perambulations we need or wish to undertake during the period of our physical existence. Physicists and mathematicians give no evidence of a loss of joy in life because of the conception of a finite universe with curved space. In fact, it seems to me that one of my mathematical friends derives a special kind of delight from the belief that a frictionless ball projected before him in a so-called straight line would eventually hit him in the back of the head.

There seems to be enough within a finite cosmos to occupy to the fullest degree the faculties of all the physicists and mathematicians that the earth is likely to produce within any period of time with which we need be concerned. Why, then, should any one be distressed by consideration of the fact that, by the very nature of the process of observing and thinking, we are confined within limits which are not likely to cramp us in our lifetime or even our descendants within a million years? The conditions we meet can be faced with unalloyed joy. No engineer weeps because he can not lift himself by his bootstraps, however

pleasurable an exercise that might conceivably be. Ordinarily, we do not like to go in circles, but there is no objection to a circular path if the circle be large enough. Such are the circles which we *always* follow afoot, or in automobile, train, steamship or airplane. And such are the paths in which our minds must travel, whether we be biologists, mathematicians or philosophers. It is a fact that every one knows, but regularly ignores, that if there were a perfectly "straight" road from New York to San Francisco, it would go far into the bowels of the earth; one would need no gasoline to coast the first half of the distance (drawing nearer to the center of the earth), but the latter half would be a long *up-hill* climb, although straight! It is only as a matter of convenience that we speak of straight lines in travel. Equally, it is only for convenience that we speak of reality in the world of thought.

In our further discussion, let us be guided by the principle of convenience, and let us treat of living beings and of objects just as if they were exactly what in practical life we conceive them to be. *It is the only way we can treat them!* I shall not think of you as figments of the chemical activities within the pyramidal cells of the cortex of my cerebrum, and you, I hope, will not look upon me and my phrasing of thought as a mere protoplasmic nightmare. We will assume ourselves and everything else to be just as real as they really are to us. For all practical purposes, we can forget the limitations previously mentioned, although they have a place somewhere in the background of our minds. Let us then look at protoplasm as a real substance and examine its character more concretely.

Some Qualities of Protoplasm

The first quality of protoplasm to command our special attention is its *instability*. There is nothing in the world as we know it more eternally unstable than protoplasm. While this is a well-known characteristic of the substance, I doubt if it always receives the conscious recognition it should have when we compare living with non-living chemical substance, when we assume, as we are naturally inclined to assume at times, that conceivably we will be able to take non-living substances and combine them in such a way as to produce living substance. The instability of protoplasm is not a mere example of the wearing away of a substance in which energy has been stored in the past; nor does it appear to be comparable to any ordinary reversible chemical reaction; nor even to an ordinary autocatalytic action (Gortner). It is an instability manifesting itself in so many directions that the condition at any future time has never been found to be entirely predictable from a knowledge of the past.

In respect to the origin of species or phylogeny we speak of "descent with modification." In respect to individual lives or ontogeny, we may well speak of *persistence with modification.* We will return to this thought again. Suffice it to say now that it is simply inherent in protoplasm to be reorganizing itself at all times. Stability in protoplasm spells death. If protoplasm is ever synthesized in the laboratory, the chemist must not only find the right groupings of materials in an extremely complex system, which he may well be expected to do; he must also get into that system, or find in it, this quality of eternal instability and something more which we will refer to in a little while. The Frankenstein conception had in it at least a germ of biological truth!

Possibly one can not always with certainty apply the qualities of the parts to the whole, but it seems reasonable to adopt, at least as a working hypothesis, the idea that instability will be a quality of any body made of protoplasm or of any combination of protoplasmic masses. As individuals we are combinations of

protoplasmic masses, and, therefore, both instability and unpredictability seem to become qualities of individuals. Social groups, academic groups, religious and political organizations, all these are combinations of protoplasmic masses and therefore by hypotheses, at least, are possessed of the fundamental quality of instability. We may assume that self-reorganization is an eternal quality of any social group. It is, then, not only in line with experience, but also a safe and reassuring philosophy of life to recognize that there is no logical possibility of attaining a stable economic, political or intellectual system. Stability may be death to them as it is to their protoplasmic basis.

The second fundamental quality of protoplasm, which appears to be in some respects a paradoxical corollary of the first, is its *approximate stability* (or constancy). Although living protoplasm is always in process of change, or at least possesses uninterruptedly the capacity for change, it nevertheless manages to remain essentially the same thing. It would not be protoplasm if it did not change, but, with all its continuous reorganization, it manages to maintain a relatively fixed organization or to proceed through a definite and roughly but not absolutely predictable series of conditions of organization. Any protoplasmic body might be regarded, as some one has said, as a vessel through which streams of matter and energy are flowing; but the matter and energy in passing participate in a definite organization determined in great part by the vessel.[1] The vessel seems to have an initial and characteristically changing organization; that prevailing at one moment determines the organization at another, and so on. The embryologist and the student of regeneration might have much to say here, but we can not go further now into a discussion that borders on the metaphysical or that might bring us before long against the impassable barrier that inevitably bounds our thought.

Parenthetically, there are probably some millions of different kinds of living organisms in existence in this day; each of these kinds is made up of millions of recognizably different individuals, and every individual, even among the Protozoa, is apparently made up of thousands or millions of different units of protoplasm; so that we arrive at astronomical figures if we attempt to enumerate the number of different protoplasmic units in activity at the present moment, all undergoing change, but remaining to a great extent unchanged. Gradual reorganization, without loss of characteristic *organization-control,* continues until, after a shorter or longer period of time, change, adaptive change, for some reason, becomes impossible, when the protoplasm becomes stable and, accordingly, ceases to be living protoplasm. This is the fate of cells, of individuals, of species, and seemingly of societies and of political and economic systems. Nevertheless, somewhere and somehow life goes on, and so do societies and politics, from seed that has been given off to shoot, flower and fruit, and to die after giving off other seed.

The biochemist who manufactures protoplasm must, therefore, introduce into his combination of materials both a condition of instability and a condition of stability enduringly characteristic of his particular protoplasmic product, but enduring indefinitely only through the power of reproduction from isolated parts—parts that become self-continuing and self-reproducing wholes.

The third quality of protoplasm to concern us now is its *inadequacy* as a basis of life. Nothing, indeed, could be more useless for the maintenance of life than protoplasm by itself. Its very instability demands interrelations with

[1] Furthermore, the streams of energy and materials flowing in have little relation immediately to the amounts flowing out, although in the long run there is no violation of the laws of thermodynamics.

outside or non-protoplasmic materials. In a sentence notable for its conciseness, Huxley reduced the protoplasmic doctrine to seven words: "Protoplasm is the physical basis of life." However exactly this statement fulfils the requirement of being truth and nothing but truth, it is certainly *not* the whole truth. Obviously, protoplasm is not the whole physical basis of life, since there is no manifestation of life without something in addition to protoplasm. Free oxygen or the equivalent is just as necessary to life as is protoplasm. All manifestations of life, as we now know them, are in the nature of responses to the addition of oxygen and other changes in the environment. Philosophers and biologists in general have recognized this truism and express it in such terms as "life is response."

It is the very responsiveness of protoplasm that must long, and conceivably forever, baffle the chemist in the analysis and reconstruction of protoplasmic behavior. I readily conceive of the complete analysis of protoplasmic substance and the *partial* reconstruction of protoplasmic behavior, but while keeping an open mind, I go no further now. If this seems to brand me as a vitalist, it is asked only that judgement be reserved for a short while.

Chemistry and Life

Life has a chemical basis and all the activities of living things, all the phenomena of life, may be the result of chemical reactions; at the very least they all appear to be accompanied by chemical reactions. It requires no argument to convince present-day biologists of these facts, although there may be differences of opinion in reference to the implications. We may cite just two or three sorts of facts which justify the broad statement just made. So far as we can tell from all observations, every manifestation of life, including mental and emotional as well as bodily action, results in the production of certain chemical products or wastes and in the demand for additional chemical substances, presumably for rehabilitation and reprovisioning of the tissues that were in action. If this were not evidence enough, we have the further condition that most of what we have learned about the structure of protoplasm and its changes during activity, physiological or embryological, is based upon detectable chemical change. What, for example, do we know about the mechanism of heredity, chromosomes, asters, chromomeres, etc.? Little more than what we have learned from the differential results of chemical reactions permitted to take place upon material representing a succession of stages of cell division, maturation of germ cells, fertilization, etc. A series of cells of different ages, when subjected to identical chemical treatment (fixatives, stains) gives us different end-products of chemical reactions; we see results that we identify as prophase, metaphase, etc. The chemical treatment applied was the same for all, but the end-products are subject to arrangement in a series parallel with the flow of time. We are bound to assume, I believe, that a series of unknown chemical reactions were occurring in the protoplasm and that it was, of course, the changing chemical constitution that conditioned the protoplasm to give the sequence of pictures that to us represent stages in mitosis, meiosis, etc. What we know, then, in regard to the series of activities is very largely what the chemical reactions have permitted us to see. Corroborative evidence from observation of living material convinces us that the chemical evidence is authentic.

Assuming, then, as we well may, that all the manifestations of life have a chemical basis, it might seem theoretically possible to hope for a time when the phenomena of protoplasm may submit to complete interpretation in chemical and physical terms, when a book of formulas, figures and expressions denoting atomic and molecular organization, nicely balanced reactions and diffusion and

osmotic rates might answer as a textbook of embryology or physiology. While no one would be so bold, at the present time, as to suggest the possibility of such a realization in the lifetime of any one now living, or in that of our immediate descendants, it may be suggestive to take a brief glimpse at the magnitude of the task.

In the first place, it should be understood that up to the present time not one single organic activity has been reduced to chemical terms. Let us assume that we have a tank with a million young free-swimming oysters, all at the stage when they should have settled down to the sedentary and steady life that well-behaved oysters are supposed to lead. In our experimental tank, however, they merely swim about in a scandalously irresponsible manner, getting nowhere and doing good neither to themselves nor any one else. Some one adds a trace of copper, as by dropping a penny into the tank, and the oysters promptly settle down, staking claims, as it were, to small areas on the bottom or sides of the aquarium where they will embark individually upon model careers of oyster life.[2] A normal behavior pattern has been interrupted for lack of the proper quality of a particular chemical element. Once this is supplied, the behavior pattern is completely restored.

But now let us suppose that the trace of copper had been added ten hours sooner, at two o'clock instead of at twelve. Would the oysters have settled? Not at all. In the course of the development of the oysters, between two and twelve o'clock changes had occurred. Predicate, if you will, that these changes were of a chemical nature, and reducible theoretically to a series of complex formulas leading up to a formula or combination of formulas, applicable at the moment the copper was introduced to effect a radical change in the mode of life.

Now if we assume that there were a thousand cells in the oyster at the stage of the beginning of our second experiment and that within each cell there were a thousand protoplasmic units in the form of genes, mitochondria, plasmosomes, protein molecules of nuclear and cell membranes and other components of the cell, we have a million or more possible chemical agents in each larva. It may be a theoretical assumption, but it seems a fairly reasonable one, that the greater proportion of this million or more biological units were performing some sort of essential activity at least once a second. Without involving ourselves too much in mathematical technique, we seem to have arrived by conservative procedure at a conclusion that some billions of chemical reactions must have taken place during the period of a few hours between the beginning of the observation and the time of settling. In short, to explain in chemical terms the activity that was precipitated by the introduction of copper into the tank, we need to lay the groundwork by following a billion or more preparatory actions. No doubt many of the chemical reactions concerned are duplications, but there is still every reason to believe that the diversity in the fundamental protoplasmic activities and chemical reactions is very great and great enough to justify the present argument in principle, at least.

The difference between the biochemical problem here and the ordinary problem in the chemical laboratory merits some thoughtful consideration: The time element, which figures, of course, in every chemical reaction, plays a so much greater and more significant and baffling part in the biological problem. This, of course, offers a whole field of thought and speculation into which we must not enter at the present time. Obviously the task of reducing the development of the larvae to chemical terms assumes the appearance of an exceedingly formidable one.

(To be concluded)

[2] Alluding to work of H. F. Prytherch, *Ecological Monographs*, 4: 47–107. 1934.

INBORN RESISTANCE TO INFECTIOUS DISEASE

By Dr. LESLIE T. WEBSTER

LABORATORIES OF THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH, NEW YORK, N. Y.

WHY are certain individuals spared during epidemics of infectious disease? The ancient notion stressed by Hippocrates was that some are endowed with a greater constitutional resistance than others, and to-day practising physicians still regard certain families and individuals as differing markedly in their ability to ward off prevalent infection.

The epidemiologist, however, has, for the most part, neglected this early theory and concentrated his attention upon the rôle of the inciting agent—the bacterium or the virus. His findings have come to form the basis of the current theory of epidemics, which is briefly summarized as follows (Text-Fig. 1). At the outset of an epidemic individuals in the population are supposed to have a uniformly low resistance. The epidemic is caused presumably by the sudden or gradual increase in virulence of an organism already present in the community or by the importation of an already highly virulent agent. The unfortunate individuals who succumb or contract a severe form of the disease are supposed to have encountered by chance large quantities of these virulent organisms. The epidemic is terminated according to this theory by a decrease in virulence of the causative agent and by an immunization of the remaining population constituents. This immunization presumably takes place in those who by chance have encountered only small doses of or less virulent organisms and hence have contracted a mild disease or hidden infection and thus developed a specific protecting mechanism. Such an epidemic theory ascribes the fate of the individual largely to chance.

This theory of the epidemiologist has now been subjected to an experimental study in the Rockefeller Institute according to new methods designated "experimental epidemiology." Populations of animals, usually mice, are assembled, some epidemic-producing organism is introduced, and the subsequent spread of infection studied under relatively natural and yet partly controlled conditions. Events are observed which closely parallel those occurring in human epidemics, hence an opportunity is afforded for the first time to study directly the question of what causes epidemics and especially why certain individuals are spared during epidemic times and others are not.

First, it developed that the virulence of the agent is not a fluctuating but a fixed property during the course of epidemics. Second, it was shown that population resistance could be altered experimentally and that such alterations incited or terminated epidemics in a predictable manner. Moreover, this knowledge renders the above current epidemic theory untenable and offers a more ready explanation on the basis of only one remaining assumption—differences in individual resistance (Text-Fig. 2).

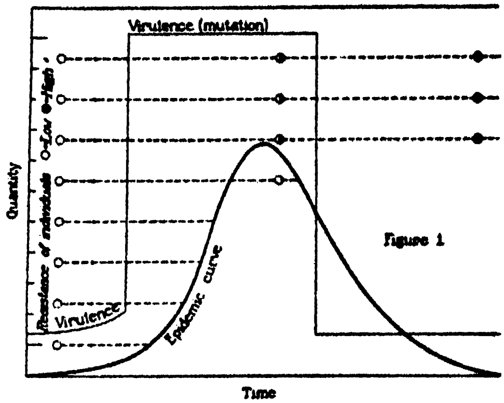
The "experimentally developed" theory states that an epidemic is caused by an agent of high yet stable virulence introduced from without or by a general lowering of the average level of resistance to the agent already present in the community. This lowering of population resistance is followed by multiplication of the causative agent in already infected hosts and consequently an increase in amount or dosage of the agent

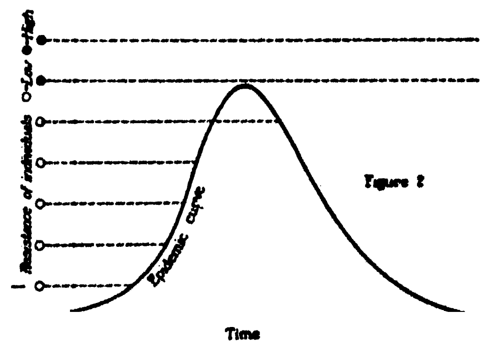
to which the community at large is exposed. This increase in dosage is the immediate cause of the epidemic whether the agent is introduced from without or already present within the population. Also in either case it is assumed that the individual constituents of a population differ widely in resistance, that those who first succumb or contract severe illness do so because at the outset they were most susceptible, and that those who escape entirely or with minor illnesses do so because at the outset they were more resistant. The epidemic curve is thus assumed to describe the differences in resistance of individuals and the average resistance level of the population to the disease-producing agent.

To test this assumption that individuals do actually (A) differ in inherent resistance and (B) succumb or escape an epidemic according to this initial resistance has been a matter of 15 years' study. To settle the first point required selective breeding experiments for some twelve generations; to demonstrate the second point epidemiological experiments were carried out for the first time with individual animals whose initial resistance was known and predictable.

(A). If an individual succumbing early in an epidemic is regarded as being inherently less resistant (rather than more unlucky) than the individuals who escape, it must follow according to genetics that its progeny must likewise be less resistant. By experiments on some 500 individuals it was found that those succumbing early in epidemics actually bear progeny more susceptible than those which escape. Thus our assumption became established that individuals differ profoundly in their inherent resistance to a given infection.

(B). To test whether certain epidemics are due to fluctuations in population resistance and whether those individuals who escape are those most resistant at the outset, populations must be made up





DIAGRAMS REPRESENTING MECHANISM OF EPIDEMICS ACCORDING TO CURRENT (FIG. 1) AND EXPERIMENTALLY DEVELOPED (FIG. 2) THEORIES.

of individuals whose resistance is known. This has not been possible until pure-bred lines of mice of known and uniform resistance were developed. From the progeny of resistants and susceptibles described above, however, (A), continued inbreeding and selection have been practised for fifteen generations until now lines of mice are at hand, generally indistinguishable except that one is 10,000 times more susceptible to a given infectious agent than the other. With different proportions of these resistants and susceptibles, various populations have been set up and a natural infection allowed to spread with the following results. If the population is comprised wholly of resistants, no disease or epidemic results. If the population consists entirely of

susceptibles, an explosive epidemic occurs fatal to nearly all. If the resistants and susceptibles are combined in different proportions and daily increments of each are added, the severity of the epidemic depends entirely upon the number of susceptibles and, with very few exceptions, the susceptibles alone are involved (Text-Fig. 3). The survivors of any given epidemic are almost entirely those individuals known at the outset to be inherently resistant. No acquisition of specific immunity on the part of the very occasional surviving susceptible has been observed.

Applying an experimentally developed theory of epidemics to human epidemiology involves certain difficulties. First, it is hazardous to reason by analogy from artificial experiments to field observations, where so many unknown and perhaps uncontrolled variables are involved. The experimental theory, however, rests upon data gained from a controlled study of six native animal infections observed under conditions as closely approximating nature as possible. Again, the facts of human epidemiology have been gleaned under circumstances in which many variables operate and relatively few are controlled—hence they are subject to a limited interpretation. The present discussion is confined, therefore, to those human infections whose nature and specific agent are fairly well recognized.

First of all, there are human infections whose prevalence fluctuates but little during a given year. These, of which tuberculosis is an example, are associated with causative agents whose virulence under natural conditions apparently remains stable. Their relatively high incidence in winter and their selective incidence appear to be due to differences in the seasonal resistances of populations and to individual differences in resistance.

The fluctuating or epidemic infections of man may be divided crudely into those which are blood-borne, food-borne or air-borne. Those which are blood-borne—yellow fever and malaria, for example—usually arise from infected human beings or animals whose blood has contaminated some insect vector following bite. This insect vector in turn pierces the skin of man and introduces the infectious agent into his blood stream. The prevalence of these infections fluctuates

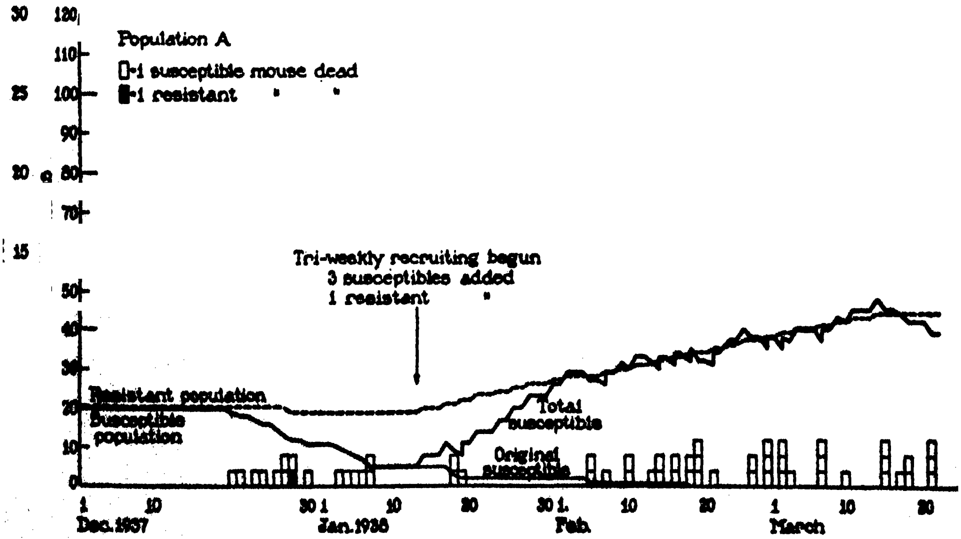


FIG. 3. SPREAD OF B. ENTERITIDIS MOUSE TYPHOID IN A POPULATION COMPRISED OF INNATELY SUSCEPTIBLE AND RESISTANT MICE.

markedly and epidemics occur of world-wide proportions. The infections occur chiefly in warm weather and curves of incidence parallel those of prevalence of the insect vector and of temperature and humidity. That is to say, warm weather determines the number of insects, and the number of insects determines the available dosage of the infectious agent and consequently the number of human cases. The selective incidence among individuals depends upon differences in their resistance following exposure.

The food-borne infections of man—typhoid and dysentery, for example—arise from the ingestion of food, water, milk, etc., to which the causative organism harbored by man has gained access and multiplied. These diseases are most prevalent and become epidemic in tropical climates and in warm weather. Under these circumstances the causative agent is best able to multiply in contaminated material. The increase in quantity of the agent or dosage available to the population is the immediate cause of the epidemic.

Finally, there is the group of air-borne infections—pneumococcus pneumonia, meningococcus meningitis, for example—which are transmitted directly from man to man by contaminated nasopharyngeal secretions without the intervention of any further vector. They are most prevalent in cold climates and cold weather and there may assume epidemic proportions. Some condition acting directly upon man increases carrier rates and hence dosage of disease-producing organisms available to the general population. Most probably these unknown winter conditions reduce the resistance of the general population, since deaths from all causes are most numerous at this time. And differences in individual resistance again appear to determine the selective incidence of the infection.

Altogether the experimentally developed theory of epidemics fits the facts of human epidemiology better than the hypothesis of fluctuating virulence. Indeed, perhaps a crucial test has been the successful combating of the blood- and food-borne infections through a direct attack upon the dosage factor, that is, the control of insects and food and water contamination.

If the fate of an individual during epidemic times depends not upon blind chance but upon this initial resistance, efforts to analyze and increase that resistance are of fundamental importance to preventive medicine. Thus far it appears that the basic inherent resistance of an animal to a given infection is not so much manifest at the portal of entry or blood stream as in the specific tissues to which the agent has a special predilection. Thus, in St. Louis encephalitis infection of mice, the nasal portal of entry of resistants or susceptibles is equally receptive and the blood stream of both contains no antibodies. But once the virus reaches its tissue of choice, the brain in this case, it multiplies rapidly in and destroys the brain of the susceptible, while in the brain of the innately resistant it gains a transitory foothold and causes little or no damage. Finally, studies now under way indicate that the level of resistance which is inherited can be altered by many environmental factors, entirely aside from specific vaccines or sera. Not the least of these factors, for example, is diet. Toward a better controlling and enhancing of the resistance levels of populations and of individual man studies are now directed.

COMMENTS ON CURRENT SCIENCE

MISTLETOE IN LEGEND AND IN SCIENCE

PRESENT-DAY customs involving the use of mistletoe as a decorative plant during the Christmas season had their origin in ancient legends and beliefs which still prevail in Europe and America among simple folk. The strange appearance of the plant together with its comparative rareness in the northern part of its European range no doubt contributed to the belief in its great potency as a general panacea for all ills, including its power to cure barrenness in women and cattle. Anything so universally "good" naturally found a place in the customs centering about the joyous Christmas season. So began the custom of hanging mistletoe, with other evergreen plants, in prominent places as a decorative for the holiday season. Though many of the beliefs once accorded this plant have been largely forgotten, the youthful folk never forget that mistletoe is an excuse for uninvited(?) kissing.

The admittedly pagan origin amongst the Druids of the magical beliefs concerning mistletoe resulted in its being barred by the clergy from churches even for decorative purposes. This appears to have been true particularly in England during the past century. Its general use and acceptance by the people of all European countries and of America, however, has served to keep alive the customs of which the significances have been forgotten.

Fancied medicinal properties were numerous among the claims made for mistletoe. Decoctions taken internally or applied externally were believed to be effective, variously, in the cures of itch, epilepsy, convulsions, general debility, weakness of vision, cramp, wounds, sores, etc., *ad infinitum*, to draw "humours from the deepest parts of the body," and to serve as an antidote for poisons. No less prominent were the superstitions attached to the plant. It was credited with insuring success in hunting, and an amulet of its leaves served as a safeguard against all evil.

The more recently discovered facts concerning this odd plant are no less interesting than these beliefs which we now know to be untrue. The common name mistletoe is applied to many of the numerous species included in the family *Loranthaceae*, which is comprised of over twenty genera and several hundred species. More commonly known, however, are the genera *Viscum* in the Old World and *Phoradendron* in the New World. In Europe *Viscum album* L. is known as the common mistletoe and occurs throughout the Continent, except in the Far North, and in temperate Asia. Likewise well known is the red-berried mistletoe, or *Viscum cruciatum* Sieber, which occurs in Spain, northeastern Africa and Syria. It is from this species that legend ridiculously derives the wood which comprised the cross on which Christ was nailed; ridiculously, because the plant produces no wood sufficiently large and strong to serve as a staff, much less a structure to support a man.

When early explorers brought to Europe specimens of American mistletoe, these were described as species of *Viscum*, but subsequent students recognized the generic distinctness of the Old World and New World mistletoes and segregated the latter under the genus *Phoradendron*. No American species of *Viscum* are known and likewise no Old World species of *Phoradendron*. In America the most widely used mistletoe is *Phoradendron flavescens* (Pursh) Nutt. This plant occurs as far north as New Jersey, west to Southern Illinois and Texas, and south to Florida. On the West Coast it is represented by the related species *P. villosum* Nutt. Both these species have rather prominent green leaves and persistent white berries.

They so closely resemble *Viscum album* of Europe that it was with little difficulty and scant need for imagination that early European colonists in America accepted the American mistletoe as identical with the familiar European plant, and transferred to it the beliefs and customs which had been built up around the mistletoe of Europe.

Mistletoe is described as a semi-parasite. It grows in the form of a shrub on the branches of various species of trees. Its connection with its host is in the form of a *haustorium* or root-like structure which penetrates the host tissue and establishes a communication between the vascular tissues of the host plant and those of the parasite. Thus it secures water, minerals and elaborated food material from the host. At the same time the mistletoes (at least the commonly known species) have large green leaves and green stems by means of which they are capable of carrying on photosynthesis and elaborating their own food materials. That the parasite depletes the host's food material is evidenced by the stunting of infected host branches beyond the locus of infection. It has been demonstrated (unpublished) that a heavily infested tree kept divested of its own leaves can not subsist on the food elaborated by the parasite. This would indicate that there is little if any movement of food from parasite to host. Investigation has revealed that the cell sap of the parasite has a much higher concentration than that of the host tissue. This acts as a deterrent of the movement of water from parasite to host.

At best it is a bizarre plant upon which we have heaped the significances of legend, healing and custom.

CORNELIUS H. MULLER

COMMON USES OF PLANTS FOR CHRISTMAS DECORATION

COMING as it does in midwinter, the Christmas season has occasioned the use of those indigenous evergreen plants available to the people. Considering also the coincidence that some of these plants were thought to have remarkable curative and even magical powers, it is not surprising that some of them were early chosen as symbolical objects and have persisted as pagan elements in the celebration of Christmas. Add to this the esthetic appeal of green leaves in bare winter and persistent white and bright red or yellow berries, and one can readily understand why their use has continued to the present day.

Mistletoe with its green leaves and white berries is known to us as a symbol of Christmas, as has already been described. No less significant are holly and fir (Christmas trees). The *Tannenbaum* (*Abies pectinata* DC.) of early Nordic Christmas celebrations has been credited with having suggested, by its erect young cones, the use of candles on Christmas trees. Since the custom of setting up Christmas trees has spread with Christianity, the custom naturally has come to lands where fir trees are not to be found. There, any substitute suggestive of fir has been employed, and the other *Gymnosperms*, such as *Pinus*, *Pseudotsuga*, *Juniperus* and *Picea*, have been most sought after. Lacking these species, evergreen oaks have been pressed into service in our Southwest, or any evergreen tree or shrub which is readily available.

Holly (*Ilex aquifolium* L.) enjoyed a magical and therapeutic reputation second only to mistletoe in early European beliefs. For the same reasons it, too, has come to be associated with Christmas. The hollies number many species, but the spiny-leafed European holly with its red berries serves as the type for Christmas decoration. Of the several American species, *Ilex opaca* Ait. most closely resembles the European species. For the sake principally of their numerous red berries, *Ilex verticellata* (L.) Gray and *Ilex decidua* (DC.) Walt. are much used in America. Their leaves are smaller,

almost entire, and, in the latter species, deciduous.

Of less significance and of diminishing use on account of conservation programs are various species of clubmoss (*Lycopodium*). These serve principally as greens for the making of wreaths. Both European and American species are abundantly gathered for this purpose.

Local customs have occasionally arisen through the lack of the older, accepted plant materials for Christmas decoration. Thus, in the Southeastern United States the so-called Spanish moss (*Tillandsia usneoides* L.), a member of the pineapple family which grows pendant from the branches of trees, is used in large quantity for Christmas decoration. The somber gray hue of this dreary-appearing plant (though it is often dyed green for Christmas use) seems not to lessen the gaiety of the season's mood.

CORNELIUS H. MULLER

FIRE-RESISTANT CHRISTMAS TREES

A CHRISTMAS tree is a serious fire hazard. The risk is especially great where a large tree is used at a public gathering place such as a school or church. A living tree draws up water and dissolved mineral matter from the soil through its roots. If the stem or trunk of the tree is cut off above the ground and the cut end placed in water while the tree is still green, the stem retains much of the water-absorbing power of the roots, and the cut end takes up relatively large quantities of water. This water-absorbing power permits the introduction of dissolved substances into the tree after it has been cut. These circulate through the tree and are carried into the foliage.

Certain chemicals are able to render wood, pine needles and other flammable materials resistant to fire. Ammonium sulphate is about the best fire-resisting material. It is cheap and effective, and can be purchased from any seed store and from most hardware stores. Calcium chloride is also effective and cheap, but not so readily obtainable as ammonium sulphate. In addition to its fire-resisting properties, calcium chloride helps to hold moisture in the foliage and prevents the needles from dropping. If calcium chloride is substituted for ammonium sulphate, the same proportions should be used.

The method for making a Christmas tree less flammable is as follows: 1. Just before treating, cut off the end of the stem, preferably at an oblique angle or in a V shape, in order that the chemical solution may have free access to the fresh wood at the cut end. 2. Weigh the tree and divide the weight by four. This will give the weight of the ammonium sulphate needed. 3. Dissolve the ammonium sulphate in water, using one and a half pints of water for each pound of ammonium sulphate, and place the solution in a glass jar, tin pail or earthen crock. A narrow-mouth container is preferable because it lessens evaporation of the solution. 4. Set the tree in the solution in a cool place and leave it there until it absorbs the solution. For best results the treatment should be given at a moderate temperature—55 to 65 degrees Fahrenheit—before the tree is placed in a warm, dry room, because *the solution is not taken up satisfactorily when the atmosphere is warm and dry.*

It should be strongly emphasized that the degree of fire resistance depends upon the amount of the solution taken up by the tree. For best results *all* the solution should be absorbed before the tree is used. If the tree has been cut for too long a time it will *not absorb* the solution and consequently *can not be made fire resistant by this method.*

A word of caution should be added. A tree may be fire-resistant in the sense that it can not be ignited by a match of electric spark, and yet may catch fire from a large flame near it. It is customary to spread

a layer of cotton under the Christmas tree to imitate snow. If this cotton should catch fire, it might easily ignite even a treated tree, therefore, decorations on or about a tree should also be treated.

MARTIN LEATHERMAN

MORE MOONS OF JUPITER

DR. SETH B. NICHOLSON has just reported to the Carnegie Institution of Washington the details of his discovery of last July of two hitherto unknown moons of Jupiter, numbers X and XI.

Four moons of Jupiter were discovered by Galileo in 1610 with the first telescope ever turned toward the heavens. These moons are from 2,000 to 3,200 miles in diameter, and so bright under favorable conditions that they could be observed with the unaided eye if they were not lost in the bright light we receive from the planet. The satellites just discovered by Dr. Nicholson are only a few miles in diameter, possibly four or five, and they are only one two hundred thousandths as bright as the moons discovered by Galileo 300 years ago. They are so faint that it will not be possible to see them even through the giant 200-inch telescope which is now under construction in California. Dr. Nicholson found them by long-exposure photographs taken with the great 100-inch reflector on Mt. Wilson.

No satellites of Jupiter were discovered from 1610 until 1892 when Dr. E. E. Barnard found a fifth with the 36-inch telescope of the Lick Observatory. This is a small satellite about 100 miles in diameter and so close to Jupiter that its period of revolution is only twelve hours. Dr. C. D. Perrine discovered two additional satellites by photography, one in December, 1904, and the other in January, 1905. These are very small moons, probably between 20 and 80 miles in diameter, and revolve at distances from the planet of more than seven million miles. An eighth satellite was discovered by P. Mellotte in England in 1908, also by photography, and a ninth, by Dr. Nicholson in 1914. The eighth and ninth satellites revolve around Jupiter at distances of about fifteen million miles in periods of about two years.

There is much more to these discoveries of Dr. Nicholson than merely adding two new moons to a planet which was already known to have nine. Eight of the eleven moons of Jupiter, including one of those recently found, revolve around the planet in the direction in which it rotates on its axis and revolves around the sun. The other three satellites revolve in the opposite direction, all at about fifteen million miles from the planet and in orbits that are highly inclined to the plane of its equator. These retrograde satellites have a bearing upon the problem of the origin of the planets and the satellites, and they have posed problems that so far have not been answered. It is interesting that the facts and theories of modern science are so interrelated that our conclusions respecting the origin and early history of the planet on which we live depend on the properties of the motions of barren and lifeless little bodies which at their nearest are about four hundred million miles from us.

F. R. M.

SUPERGIANT "NEW" STARS

"NEW" stars, called Novae by astronomers, are stars which for some reason blaze out suddenly within a day or two, rising to a brilliancy exceeding the normal by perhaps a hundred thousandfold. And almost as mysteriously, these novae within a few days lose much of their luminosity, and decline within a few months almost to their original brightness.

Novae have played important rôles in the history of astronomy. It is believed that Hipparchus (about 160–105 B.C.) made his catalogue of 1,080 stars, the first star-catalogue ever constructed, because of the sudden appearance of a brilliant star where none had previously been seen. Possibly the Star of Bethle-

hem was an unusually bright nova. Certainly a never-dying interest in astronomy was aroused in Tycho Brahe by a "new" star which appeared in the constellation Cassiopeia in 1572, and which for a time was as brilliant as Venus. In 1604 a similar and nearly as bright nova appeared in Ophiuchus. In 1901 a very faint star in Perseus suddenly became as bright as any other star in the sky. In recent years, exceedingly distant, and consequently not very bright, novae have been frequently recorded by photography.

Astronomers have long been puzzled by the explosive increase in the rates of radiation of novae. There is no known method by which their energy can be transformed into radiation on such an enormous scale, for during their periods of great brilliancy novae are truly giants in light-giving power, exceeding by far all ordinary suns such as our own. Before astronomers had become accustomed to the amazing properties of these giants, they were astounded and bewildered by the discovery of supernovae, which exceed common novae in brilliancy as much as common novae exceed ordinary suns. These supernovae have not been observed within historical times in our own galaxy of billions of stars, but in distant galaxies so far away that light requires millions of years to come from them to us.

Dr. W. Baade of the Mt. Wilson Observatory has just reported in the *Astrophysical Journal* on the eighteen supernovae so far known. On the average, each of these eighteen astounding objects at its maximum brilliancy poured out radiant energy into space at a rate exceeding that of the sun a hundred million times. In some cases, at their maxima, they radiated more energy than all the other stars of the systems in which they appeared. If a supernova should appear in our own galaxy, it might easily give us more light than the full moon. Perhaps, then, astronomers would be able to determine definitely whether the mysterious cosmic rays have their origin in the supernovae, as has been suggested as one of the possibilities of their source. If our sun should become a supernova, or even a common nova, which is very improbable,—well, then the publication of the SCIENTIFIC MONTHLY would be permanently discontinued.

F. R. M.

REEFS OF SODIUM BICARBONATE

THE "rock candy mountains" of the hobo song are approached in actuality by discovery of thick reefs of baking soda buried in the earth, perhaps the first of this material ever found in nature. It has just been identified by Dr. William F. Foshag, Smithsonian Institution curator of mineralogy, from cores brought to the surface from depths of about 300 feet under an ancient California lake bed.

Used by housewives and dyspeptics for generations, sodium bicarbonate always has been a manufactured product, made from a base or ordinary table salt by a complex chemical process. A few years ago, came the first reported discovery of any of the natural mineral. It was identified, perhaps in error, by a British geologist in a chemical analysis of encrustations scraped from the wall of an ancient Roman aqueduct near Naples. It was declared a new mineral and given a name.

Some doubts have been thrown on this discovery by further tests, so that the material identified by Dr. Foshag may be rated as an original discovery. It was found under the dried bed of Searle's Lake, California, long known as a treasure chest for rare mineral combinations. There are approximately 150 feet of brine beds, deposited from the waters of an ancient salt lake. From these beds, by means of shallow wells, potash and borax are being recovered on a commercial scale. In the pumpings a complex of other minerals is found. Some time ago, Dr. Foshag suggested that drillings

be made below the brine layers. When the shafts were driven to the 300-foot level, it was found that layers of almost pure sodium bicarbonate and clay alternated. This time, Dr. Foshag says, there is no question whatever about the identification.

From samples obtained from the lower levels of the brine deposit, he has identified another new mineral, hitherto known only as an artificial chemical compound which has been named "burkeite."

THOMAS R. HENRY

A STRANGE FISH

ONE of the world's queerest and probably rarest fishes, a thread-like eel about seven inches long, has just turned up for the second time in history at the Smithsonian Institution.

A few years ago, Dr. A. W. Herre, of the Field Museum of Natural History, found the first specimen in a brook in New Guinea. The second specimen was obtained by Dr. Paul Bartsch, of the U. S. National Museum staff, in the open sea off the coast of Cuba. It apparently was attracted by a light lure from considerable depths. Both specimens, found thousands of miles apart and the only two of their kind ever seen, were superficially very much alike, so that they can be placed without hesitation in the same genus. The Cuban specimen differed sufficiently, however, to be described as a new species by Dr. Leonard P. Schultz, Smithsonian curator of fishes.

Both Dr. Herre and Dr. Schultz classify the new fishes as belonging to the general family of eels, whose principal characteristic is their thin, elongated body structure. The Cuban specimen has one peculiarity, however, for which it is unique among known fishes, although some varieties of blennies have something roughly approaching it. This is an organ consisting of two minute bone tubes opening just back of the head and burying themselves in the flesh of the head. Some blennies have hard spines in a similar position, but nothing which could be mistaken for tubes.

There is no clue whatsoever to the function of this unique organ, Dr. Schultz says. It might be revealed by dissection of the fish, but the single specimen in the world is far too important intact to be cut up for an anatomical study.

When caught, the little eel was gray in color and almost transparent. About the size of wrapping twine in the head region, it tapered off to the size of the finest thread at the tail. It is one of the smallest of the great eel family, Dr. Schultz says, but a few others are of about the same size. Superficially, it resembles the genus of "snipe eels" which are found at considerable sea-depths over most of the earth, but it lacks the extremely characteristic jaws of this genus.

At best, Dr. Schultz believes, the creature is rare. It may be more common than the two known specimens would indicate because it is just the sort of fish which would escape systematic collectors and be caught only by accident. For the great apparent gap in its distribution, there is at present no logical explanation.

THOMAS R. HENRY

THE "PERFECT" ANESTHETIC

GENERAL anesthetics have been used to produce pain-free oblivion during surgical operations for nearly 100 years, but the search for an ideal anesthetic still goes on in laboratories and operating rooms all over the world. Large numbers of chemicals have been tested for anesthetic properties, but, while some are better than others, none of them can be called perfect.

"A perfect general anesthetic," says Professor V. E. Henderson, of the University of Toronto, Can., Faculty of Medicine, "should produce not only absence of pain and loss of memory of the operation, but complete unconsciousness and such a deep depression of the central nervous system that painful

stimuli do not produce any muscular reflexes and have as little effect as possible upon the respiratory cardiac or other medullary reflex centers. It should further produce a state of very low tonus in muscles; complete relaxation of abdominal walls, as the surgeon puts it.

"It should produce its effect quickly without setting up undesired reflexes from the respiratory passages or elsewhere, and be free from direct stimulant effect on the basal ganglia when in low concentrations in the body. Its effects should pass off quickly and completely, leaving no indication of its action. Lastly, it should allow of the inhalation of adequate amounts of oxygen throughout its administration. No anesthetic has as yet fulfilled all these requirements."

Besides these effects on the body, the ideal anesthetic should have certain physical and chemical properties. It must have high solubility in lipoids as compared with its solubility in water. Lipoids are fatty substances found in the body. The ideal anesthetic must also have high chemical stability in the body.

JANE STAFFORD,
Science Service

THE CENTENARY OF CELL THEORY

BIOLOGISTS the world over have been observing, during the current year, one of the most important anniversaries in the whole history of science: the centenary of the cell theory.

It is difficult nowadays, when everybody, layman as well as biologist, takes cells for granted (even though he may never have squinted through a microscope), to realize that only three generations ago the idea of the importance of these little living bricks of which all living things are built was as new as the sunrise.

Yet so it is. To be sure, cells had been seen before. Early in the seventeenth century, as soon as the first crude microscopes became available, observers saw these objects, either as cavities in the tissues of larger organisms, or singly as "animalcules." But though seen, they were not rightly interpreted.

It was not until 1838 that the right eyes and the right minds were applied to the cellular problem. First came Matthias Jacob Schleiden, son of a Hamburg physician, who at the age of 34 brilliantly interpreted these minute subdivisions of the plants he studied as the ultimate organized living units. He described with considerable accuracy the course of cell division, and regarded it, correctly, as the essential basis of multiplication and growth.

General application of Schleiden's theory to both plants and animals was made by another German, the zoologist Theodor Schwann, much of whose career was spent in the Belgian universities of Louvain and Liége. He found nucleated cells in the tissues of some of his animals, especially in embryonic tissues, and established the general applicability of the cell theory to all growth and development.

Erik Nordenskiöld declares, in his "History of Biology": "It is thanks to this theory that the present age has been able to work out its conception of life-phenomena as a connected whole; without Schwann, Darwinism would hardly have been victorious."

FRANK THONE,
Science Service

THE RING STRUCTURE OF SILICA AND BORON

THE versatility of carbon is proverbial among all the elements found in nature. Carbon's ability to combine with itself in two ways—either in rings or in chains—accounts for its creation of hundreds of thousands of chemical compounds.

Arranged in chains, carbon makes possible petroleum, rubber, fats, the natural oils and the solvents. When the chains are turned around and form a ring, the chemicals typified by dyes, explosives, drugs and the synthetic resins result.

Chemists have long sought to make

other elements duplicate the unusual and extremely valuable type of bonding which carbon can achieve. The *Industrial Bulletin* of Arthur D. Little, Inc., reports that they are gaining their goal in this respect; at least in some cases.

The best success has come with elements, like silicon, which are closest to carbon in chemical characteristics. Silicon, like carbon, has the ability to join up with four hydrogen atoms in a molecule. And, like carbon also, it has the power to form compounds with itself known as silanes. These silanes are analogous to the carbon compounds, methane and ethane, found in natural gas.

Boron, too, is another element which can form compounds with its own atoms. Boranes may have as many as ten boron atoms linked in a chain. Both silanes and boranes ignite in air, sometimes with violent explosions.

By joining nitrogen and boron, chemists have succeeded in making a ring compound which is extraordinarily like benzene. In fact, the compound is called inorganic benzene.

It has practical significance in that, like real benzene, it is a liquid and a solvent for oils and fats. While it is not all that one desires even as a benzene analogue it may be a step on the way to improvements that will have important industrial applications. German chemists have been working in this field and it is comforting to note that American chemists, too, are studying the reactions.

ROBERT D. POTTER,
Science Service

RESEARCH IN THE STEEL INDUSTRY

STEEL once was considered the oldster among industries which did not know that constant research is the secret of perpetual rejuvenation. A decade or more ago there was a certain amount of scorn among practical steel men for too much flavor of research scientist.

Now that attitude has changed and the industry has changed with it. Just one of the big steel concerns has some 86 laboratories that conduct research primarily or incidentally, spending a cool $1,800,000 annually in scientific searchings. U. S. Steel Corporation began its major fundamental research program on a large scale in 1928.

Evidently it is good business for steel as it is for other fields. Dr. Rufus E. Zimmerman, vice-president in charge of research and technology for U. S. Steel Corporation, feels sorry for any steel expert who retired, say, 25 years ago, and who would try a come-back. He would be embarrassed by the mere size of open hearths and blast furnaces, feel out of place in continuous mills, hot and cold rolling a multitude of flat products, and need an interpreter for the new steel lingo of "slag-metal equilibrium," "measured deoxidation," or "controlled grain size." Alloy steels, including the stainless varieties, produced in electric furnaces would puzzle him.

Off production lines at the rate of so many miles per hour come steel products that would have been minor miracles a few years ago. Take the shiny steel sheet that goes into a huge press and comes out the two sides and top of an automobile. Those several square yards of metal must not crack under the strain of the terrific stretching and must be flawless on the surface.

A thousand automobile parts must be identical twins, one with another. Each must have the same desired grain size in order to harden the same way so as to act identically in the unrelenting rush of manufacturing and assembly.

Steel is even challenging the light metals, such as aluminum, in the airplane and streamlined train field. Stainless sheets as thin as 4/1000 inch and up to 190,000 pounds per square inch tensile strength are being produced that steel may do its share in speedy transportation.

WATSON DAVIS,
Director, Science Service

CULTIVATION OF THE MATERNAL INSTINCT

Mother instinct can be aroused by any one of six substances, one of them carbolic acid, according to a report just made to the trustees of the Carnegie Institution of Washington by Drs. Oscar Riddle and E. L. Lahr of the Carnegie staff.

They had previously reported that male rats and immature females could be made to "mother" infant animals when they were given injections of prolactin, the hormone secreted by the anterior lobe of the pituitary gland at the base of the brain which was first discovered by Dr. Riddle six years ago. One of the primary functions of prolactin is to stimulate the excretion of mother's milk, and it has been used with indifferent success to increase the milk production of cattle.

They now find that the mother love complex also can be aroused by injections of progesterone, one of the female sex hormones; testosterone, one of the male sex hormones; intermedin, a recently discovered pituitary gland hormone; extracts of the whole interior lobe of the pituitary gland; and carbolic acid. Meanwhile, other experimenters have reported that the same result can be brought about by removal of the thyroid gland in males and by the removal of the pituitary gland in immature females. The last report is especially puzzling to the Carnegie Institution workers because it involves a complete absence of prolactin in the blood stream.

The milk-producing hormone, Dr. Riddle's report shows, still is by far the most potent producer of mother love. It induced maternal behavior in more than three fourths of the female and more than half of the male rats. The female sex hormone was next, producing the syndrome in about two thirds of both males and females. The male hormone caused this reaction in more than half of the females but in only 15 per cent. of the males. The newly found pituitary hormone caused maternal behavior to appear in more than half of both sexes. Carbolic acid had the same result in 40 per cent. of the females and 24 per cent. of the males. There were no discernible effects after the injection of thyroid, parathyroid and adrenal gland hormones. Other sex hormones not only did not produce maternal behavior but seemed to inhibit it when it already was present.

The new results, Dr. Riddle points out, make more difficult than ever an explanation of the physiological mechanism of maternal affection, which first appeared on earth with the warm-blooded birds and mammals and which has been one of the most potent factors in evolution by making possible a prolonged infancy in which the young can be "educated" before they have to shift for themselves. The other substances, he says, may produce the effect by stimulating the pituitary gland to secrete more prolactin. Another possible explanation is that they act by inhibiting the action of other sex hormones, both male and female. Previous experiments have been reported in which the mother love of rats was completely destroyed by removing from their diet all the element magnesium.

Dr. Riddle reported to the Carnegie trustees some critical experiments with doves. He found that when crystals of the female sex hormone progesterone were implanted in the bodies of male doves, they started sitting on eggs. Then the crystals were removed, but the birds continued to sit until the young were hatched, and then proceeded to feed them until they were ready to fly away. This proves, he says, that the maternal instinct does not require the continuous action of the hormone itself. The progesterone seems to set off a complex interglandular reaction which, once gotten

under way, persists through the normal brooding cycle.

In another experiment, the rate of crop cell increase was determined from the onset of the "broodiness" in females. At the beginning this was found to be more than six times as great as at other times. The rate was increased still further during the whole incubating period until the first signs of crop milk appeared just before the eggs were hatched. This rapid crop growth is a basic action of prolactin. The experiment proves, Dr. Riddle believes, that the hormone is operating from the very beginning of the "mothering" period, although it may not necessarily be the cause of it.

Drs. Riddle and Lahr made nearly 2,000 tests with rats in their efforts to untangle the strange hormonal complex of mother love. It is essentially, they stress, a subconscious emotional reaction in which the brain apparently plays little part. They believe that its manifestations in human beings, where it is most prolonged, probably are due to the same basic physiological mechanisms as in the lower animals, but that in all human races it is affected by a great number of conventions which render objective study difficult.

Hormones, they point out, differ little from species to species. They now are trying to obtain purer and purer extracts of prolactin in an effort to clear their experiments of any effects exerted by small amounts of other pituitary hormones.

THOMAS R. HENRY

TISSUE CULTURE METHODS IN PLANT PHYSIOLOGY

SCIENCE has a way of closing in on a problem, once a breach has been made in the wall of difficulties surrounding it, that reminds one of an army capturing a city. Fronts of the various attacking columns maintain liaison and give mutual assistance as they move toward the common objective.

One such objective is the understanding of the physiology of plant cells and tissues. If we can get a better understanding of the way the cells act separately we can know more, and eventually do more in the applied field, about the way they act in the masses we know as organs and the organism as a whole.

But it is not easy to make plant cells or tissues act as isolated units. Not until about a decade ago did any one score an initial success. Then, Dr. William J. Robbins, of the New York Botanical Garden, was able to make roots survive for measurably long periods. But he could not induce them to grow.

Dr. Philip R. White, of the Rockefeller Institute, using a culture fluid containing several mineral salts, purified cane sugar and yeast extract, grew isolated roots indefinitely. He has scores of the little flasks containing growing roots that have not been attached to the parent plant for half a dozen years.

Yet these are fully organized roots—plant organs, rather than isolated tissues in the strict sense, and certainly not isolated cells. Success in culturing tissues and cells of plants is reported from two places in France. At the Sorbonne in Paris, R.-J. Gautheret has succeeded in producing masses of "just cells" from the cambium or growth-layer of certain trees, and at the University of Grenoble Professor N. Nobecourt and A. Dusseau have stimulated pieces of carrot into growing tumorlike masses of tissue.

The road is now open to start research on how isolated living units—"just cells"—behave when the immediate influence of the parent organism-as-a-whole has been withdrawn.

FRANK THONE,
Science Service

BOOKS ON SCIENCE FOR LAYMEN

SCIENCE FOR THE CITIZEN[1]

UPON reading the title of this large volume one wonders what was the aim of its author in writing it. Has he prepared a compendium of useful scientific knowledge that will enable the average citizen to operate the machines and gadgets he will encounter in his everyday life? The books of household remedies of a generation or two ago that prescribed a treatment for every ailment, real or imaginary, are precedents for such a volume. Or has the author shown that science is a form of ethics and religion, or that it contains all of philosophy? There are plenty of precedents for such an attempt.

"Science for the Citizen" is not an amateur engineer's handbook, nor a dissertation on philosophy or theology in the terminology of science. It is simply a book on science—physical science, engineering science, biological science, mental science. It is science in its historical development; it is the science of to-day, and it often looks toward science of the near future. It is astounding in the range it covers and in the enormous number of particularities it treats. In these respects the only comparable volume is H. G. Wells's "The Outline of History."

Science has become so varied and extensive that no man can become an expert in all of it. For nearly two generations it has become more and more specialized, both because of the impossibility of mastering all of it and also because of a too frequent false pride in ignorance of all except a very narrow field. These have been the days of exhaustive treatises on restricted subjects, which only specialists can understand. Now we have a book on all science in the grand style. It is quite likely that a specialist in each of the many fields it treats might complain that some of the statements are not exactly true without qualifications, or that they are not given proper relative emphasis. But we may inquire whether experience justifies confidence that the specialist always states only what is true, or whether he sets forth his own subject in proper relation to other fields. Judged by these standards he has generally proved that he could not be trusted.

Another method of surveying all science is for specialists in the various fields to produce a book in cooperation, as has several times been done. When the participating authors have gone so thoroughly over the contributions that each author has learned how imperfect his work has been for the purpose for which it was written, and has then corrected it, the results have been happy. Otherwise, they have not been very satisfactory. But there is much to be said for one man attempting to cover essentially the whole range of science, as Hogben has done. Outside of his own field he approaches the various subjects as his readers will approach them. He will write with the enthusiasm, and sometimes with the naiveté, of the discoverer. He will be eager to share his new knowledge with his friends. He will not be restrained by doubts nor feel under obligation to qualify endlessly his statements. He will be a crusader with plumes waving. All these things are illustrated abundantly in the work by Hogben.

It would be unfair not to insist that "Science for the Citizen" is a work of enormous content that can have been produced only by a prodigious amount of work. The author frankly and enthusiastically sets out to tell his readers

[1] By Lancelot Hogben. xxxii + 1082 pp., 480 illustrations, $5.00. American Edition. Alfred A. Knopf, New York.

what science is—not science softened and sugar-coated, but science that requires our best faculties for its comprehension. In the "Author's Confessions," which is or takes the place of a Preface, expressing the faith of the author in his public and being an indirect statement of his purpose, appears the following:

> In the Victorian age big men of science like Faraday, T. H. Huxley, and Tyndall did not think it beneath their dignity to write about simple truths with the conviction that they could *instruct* their audiences. There were giants in those days. The new fashion is to select from the periphery of mathematicized hypotheses some half-assimilated speculation as a preface to homilies and apologetics crude enough to induce a cold sweat in a really sophisticated theologian who knows his job. . . . The clue to the state of mind which produces these weak-kneed and clownish apologetics is contempt for the common man. The key to the eloquent literature which the pens of Faraday and Huxley produced is their firm faith in the educability of mankind.

After the recent sultry strivings for paradoxes and startling statements respecting creations, an exploding universe and scientific inferences respecting the characteristics of the Almighty, such words as those of Hogben are like a refreshing sea-breeze.

Hogben does not divide his material into mathematics, physics, zoology, etc., but he immerses it in the currents of human progress by grouping it in five conquests: The Conquest of Time Reckoning and Space Measurement, The Conquest of Substitutes, the Conquest of Power, The Conquest of Hunger and Disease and the Conquest of Behavior. No brief statement can give an adequate picture of the comprehensiveness, thoroughness and originality with which the author explains the progress of science under these five major headings. An attempt at any details where there is so much to be described would be misleading because of its inevitable inadequacy. If the author's faith in his fellow men is justified, his work is a success. And its success will be due in part to the very excellent illustrations of J. F. Horrabin, who also illustrated "Mathematics for the Millions," by the same author.

F. R. Moulton

ANIMALS WITHOUT BACKBONE[2]

Many universities have made noteworthy contributions both to knowledge itself and to methods for making this knowledge available, but few have undertaken as extensive a program in the latter field as has been done by the University of Chicago. Not only has a new program of study been instituted but new text-books have been written to meet the needs of the new courses. The most recent of these in the Biological Field, "Animals without Backbones," by Ralph Buchsbaum is especially interesting, for in many ways it departs widely from conventional texts. Its physical make-up is decidedly modern, and in places might even be called modernistic. A definite attempt has been made to have the book attractive so as to appeal to readers and make study easy and interesting. Its many illustrations are well done and the photographic material adds much to the value of the book. If a good illustration is worth a thousand words, as has been claimed, then this volume with its sixty odd pages of photographs in addition to the many drawings scattered through the three hundred and forty-two pages of text is actually the equivalent of a much larger volume.

The chapter headings are so worded that they catch the attention and whet one's curiosity. The various groups of invertebrate animals are clearly presented with a well-balanced distribution of materials so that no phylum has a disproportionate amount of space devoted

[2] An Introduction to the Invertebrates. By Ralph Buchsbaum. ix + 371 pp. Illustrated. University of Chicago Press. $3.50.

to it. This in itself is rather unusual, for it is so easy for an author to overstress any group in which he is especially interested. General principles are discussed in separate chapters, which is probably a good way to handle the material, but if they had been used to show developmental relationships they would have served to tie together much material which is otherwise unrelated.

The book is well arranged to meet the needs of courses in which Invertebrate Zoology is allocated about a semester's time whether these be listed as Invertebrate Zoology, survey courses or General Biology. It makes no pretense of being an advanced text, although it might well be used as an aid in such courses because of its fine collection of photographs.

At first glance it appears to be a very new type of text, but after reading it with great interest and considerable care I came to appreciate that it differs from the older texts much as modern college students differ from those of thirty years ago. A picture of a group of that period shows a very different-looking student, but after all the differences are in dress and customs. Fundamentally there is but little difference.

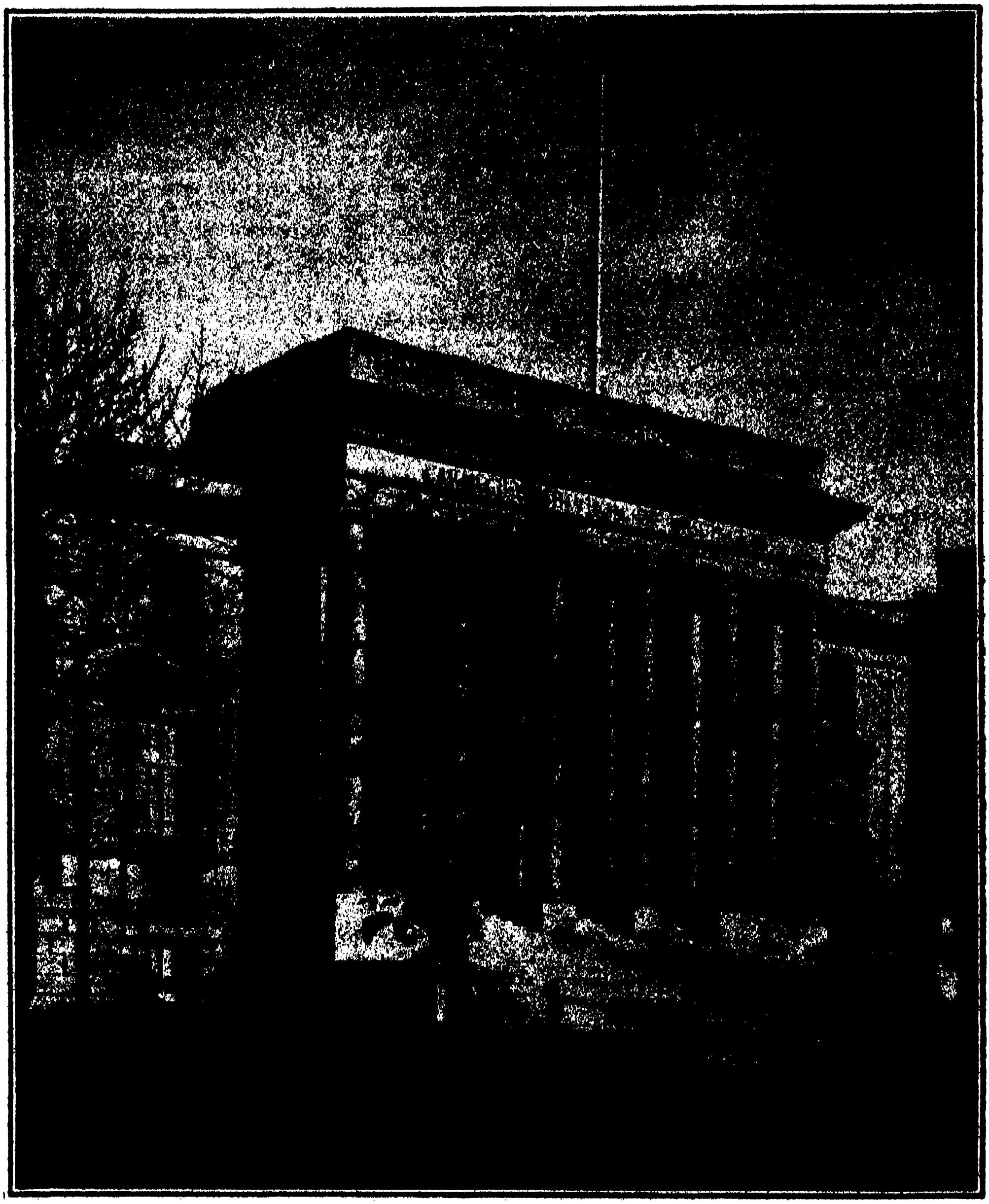
DONNELL B. YOUNG
THE GEORGE WASHINGTON UNIVERSITY

THE TROUBLED MIND[3]

THE author, according to his preface, purposes "to present a description of nervous and mental diseases in simple terms and to state some original theories concerning the nature of these disorders." In a series of 65 short chapters he gives a very considerable number of case histories to illustrate his comments on such subjects as compulsion neurosis, traumatic hysteria, epilepsy and the various types of the frank psychoses. Although the preface intimates that the book was written with the medical student in mind, it is, as a matter of fact, so oversimplified as to appear to be written down to the grammar school level. The case histories are extremely sketchy, and the explanation given by the patient as to the exciting cause is naively accepted without any suggestion that there might be any more fundamental cause for the symptoms. The author is apparently so wrapped up in his thesis of "to" reactions and "from" reactions that he omits entirely any reference to the extremely significant contributions of Freud to the understanding of the mechanisms of mental disorder. Even in the discussion of the frank psychoses there is an extremely lax use of terms, and at least one of his presumed cases of so-called paranoia is obviously a recurrent depression with feelings of suspicion rather than one of the classification to which it is attributed. It is astonishing that any modern-day psychiatrist would use such an antiquated word as "lunatic" or "lunacy," yet we find these words employed without any suggestion that they have no place in the psychiatric vocabulary. The book, on account of its oversimplification, its inaccuracies and its very serious omissions (there is hardly a suggestion in the book, for example, of the important rôle played by sex in mental disorders) can not be recommended either for the physician or the lay reader.

WINFRED OVERHOLSER, M.D.
SAINT ELIZABETH'S HOSPITAL,
WASHINGTON, D. C.

[3] A Study of Nervous and Mental Diseases. By C. S. Bluemel. Published by Williams and Wilkins Company, Baltimore, 1938. ix + 520 pp. Price, $3.50.



ADMINISTRATION BUILDING OF THE CARNEGIE INSTITUTION OF WASHINGTON
AS IT APPEARS SINCE COMPLETION OF THE EXTENSION. ENTRANCE TO ELIHU ROOT HALL, THE NEW OFFICES AND THE EXHIBIT ROOMS IS AT LEFT CENTER. UNDER SUPERVISION OF THE ARCHITECT, MR. WILLIAM ADAMS DELANO, BUILDING OPERATIONS BEGAN IN SEPTEMBER, 1937. A COMMITTEE OF THE TRUSTEES, FREDERIC A. DELANO, ROBERT WOODS BLISS AND HENRY R. SHEPLEY, WITH J. MONROE HEWLETT, THE ARTIST, DEVOTED MUCH THOUGHT TO THE DECORATION OF THE HALL IN ORDER THAT, WHILE HONORING MR. ROOT, THE GREAT SCOPE OF THE INSTITUTION'S ACTIVITIES MIGHT BE APTLY SUGGESTED THROUGH ALLEGORICAL REPRESENTATION.

THE PROGRESS OF SCIENCE

ELIHU ROOT HALL OF THE CARNEGIE INSTITUTION OF WASHINGTON

Dedication of Elihu Root Hall marks the consummation of efforts initiated eight years ago by the trustees of Carnegie Institution to provide adequate facilities for conduct of the interpretational program of the institution that has been in course of development during the administratorship of President Merriam.

Entering the hall at the rear, the visitor's eye most quickly comes to rest upon the proscenium arch and above it the dedication: *To Elihu Root whose vision wisdom and devotion to the advancement of knowledge remain a source of inspiration.*

This inscription, framed by the intertwining branches of trees that rise on either side of the archway, is an expressive characterization of the interest taken in the affairs of the institution by Mr. Root, of whom President Merriam has said: "His influence will continue to be felt, and his voice to be heard, through the coming years, however far they may stretch."

On either side wall, at left and right of the stage, groups of heroic figures—astronomers, geographers, explorers—typifying the research workers of the institution, are represented as gazing in thoughtful contemplation upon the heavens, upon the waters beneath the heavens, and upon the lands bordering these waters—a range, indeed, that encompasses all the fundamental problems upon which modern investigators are at work.

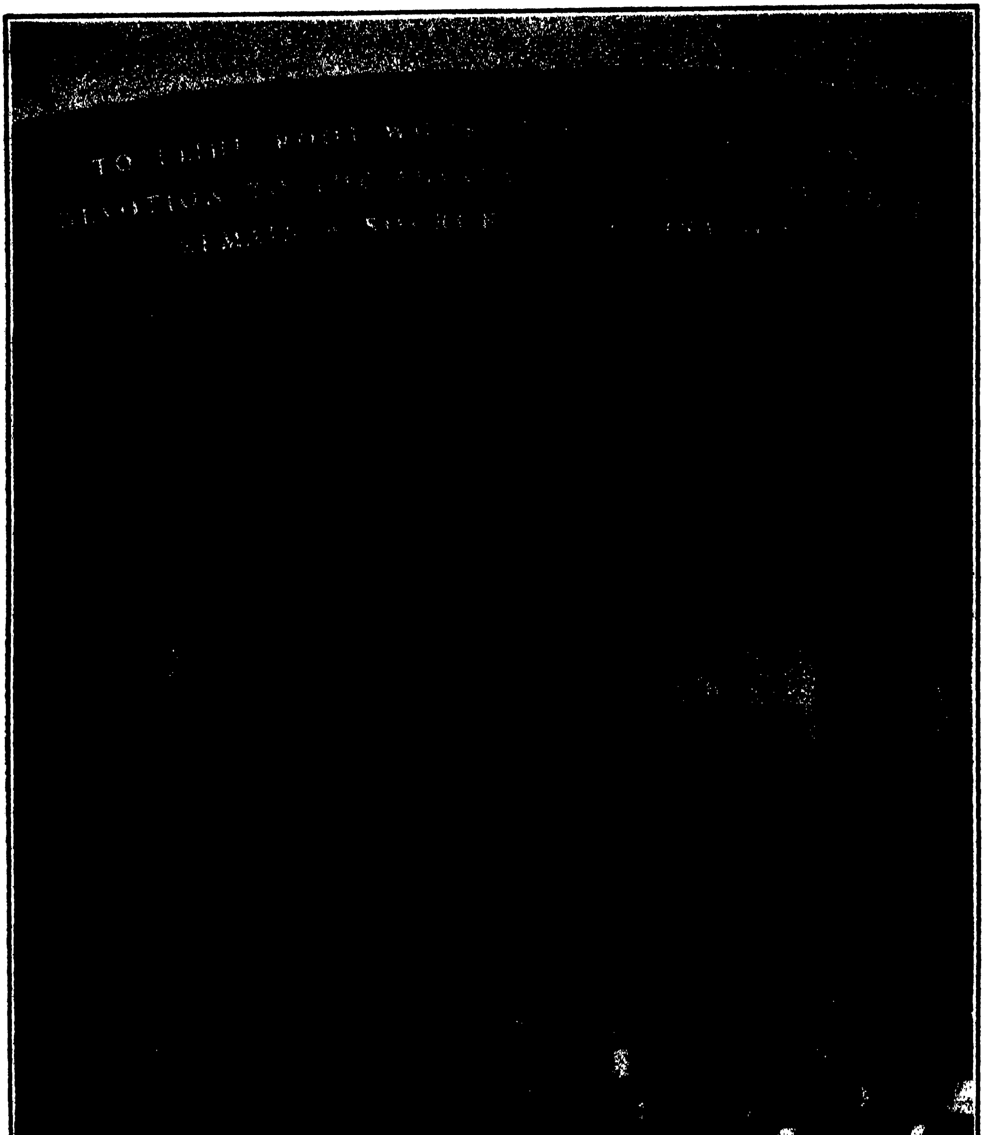
The earth's curvature, as depicted on the side walls, is such that the rear wall of the Hall presents an expanse of sky that is unbroken except by the balcony. Against this expanse flocks of wild geese and of pelicans are shown in formation, winging their unerring course through the heavens—apt symbol of the certitude which the scientist seeks to achieve in his study of the universe.

Entirely encircling the room at base of these murals and binding them into a unit, are the incomparably majestic lines of the psalmist: *The heavens declare the glory of God; and the firmament showeth his handiwork. Day unto day uttereth speech, and night unto night showeth knowledge. There is no speech nor language where their voice is not heard.*

Another conspicuous feature of the auditorium is afforded by the transparencies set into the ceiling. These were made from actual photographs of the sun and moon taken at the Mount Wilson Observatory.

The transparency of the sun at the center is four feet in diameter. The photographs from which it was made were taken with the spectroheliograph, an instrument by means of which the sun can be photographed in the violet light of its glowing calcium, or in the red light of its glowing hydrogen, or in other spectral colors where the glow of gases in the sun is of sufficient intensity for the purpose. By shutting out all the rays from the sun except certain wave-lengths of calcium or certain wave-lengths of hydrogen, as the case may be, the respective photographs will reveal details in the sun's atmosphere which are lost in the tumult of mixed elements when photographs are taken in the usual way.

This transparency of the sun represents a combination of two photographs, one of the sun's disk, taken with the violet light of calcium and showing the sunspots particularly well; and one of the seeming edge of the sun taken with the red light of hydrogen and showing especially the so-called prominences of the sun, which are flames shooting up from it with incredible speed to distances



AN INTERIOR VIEW OF ELIHU ROOT HALL

of hundreds of thousands of miles, even to a million miles in one instance recently photographed and measured.

The transparencies of the moon are each twenty inches in diameter and show the moon in eight phases arranged in natural sequence and representing one complete lunation of twenty-nine and one half days. The photographs from which they were made were taken at the Newtonian focus of the great 100-inch telescope.

Although in every instance the transparencies are flat disks of glass they give the illusion of sphericity; this is merely because one is accustomed to thinking of the sun and moon as being spherical.

Completion of Elihu Root Hall and its system of engirdling offices, conference rooms and exhibition corridors focuses

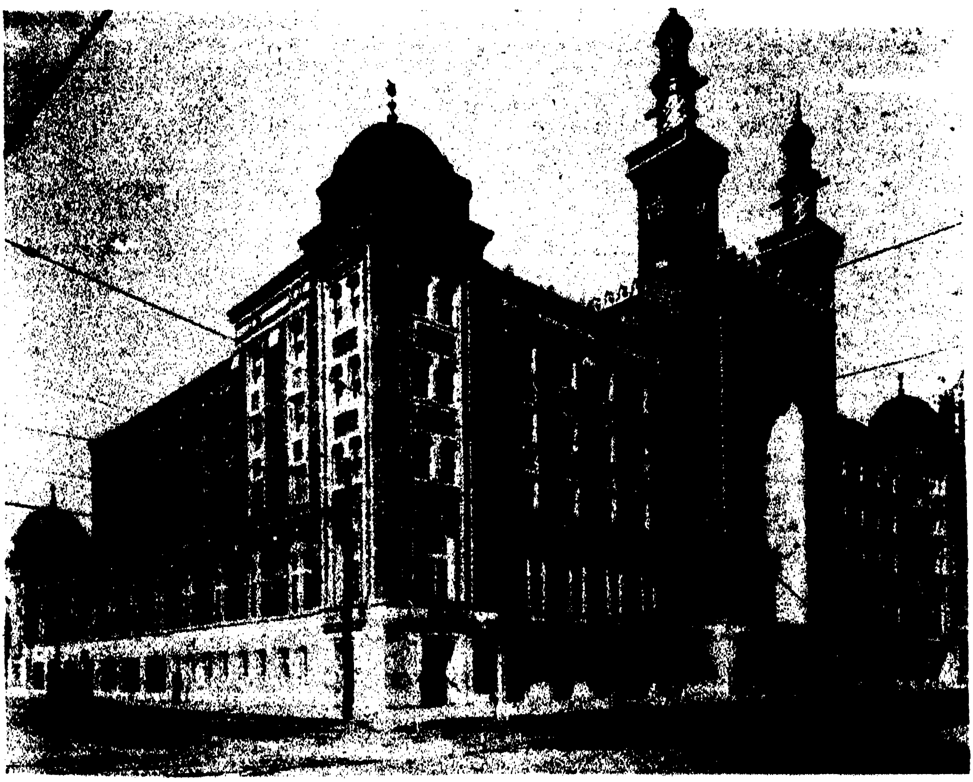
attention upon the program which the institution has developed of explaining and interpreting the significant things derived from its investigations and of making such interpretations widely available, for it was the urge of this program, primarily, that led to erection of the new building.

THE AMERICAN ASSOCIATION MACHINE

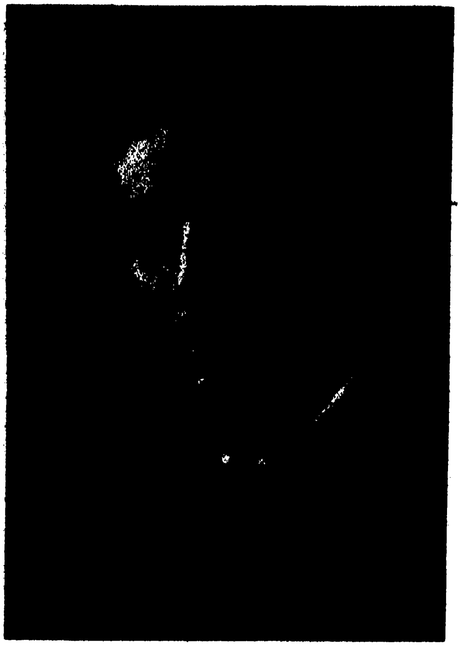
PERHAPS the word "machine" is not quite appropriate in the title of these descriptive remarks about the work of the American Association for the Advancement of Science, for, in the first place, "machine" is a reminder of things political and, in the second place, I am really referring to the forces that make the association's machine function.

Since about two hundred scientific sessions will be held at the meeting of the association in Richmond in about four days, it is evident that from twenty to forty of them must be going on simultaneously most of the time. Back of every session there is an enormous amount of planning. Even the physical preparations are formidable, for adequate seating arrangements must be provided and assigned for all of them, and many of them require special equipment such as lantern slide projectors, motion picture projectors or microscopes. But, as I have indicated, I am not speaking of these things. Vergil said, "I sing of arms and a man"; I sing only of men.

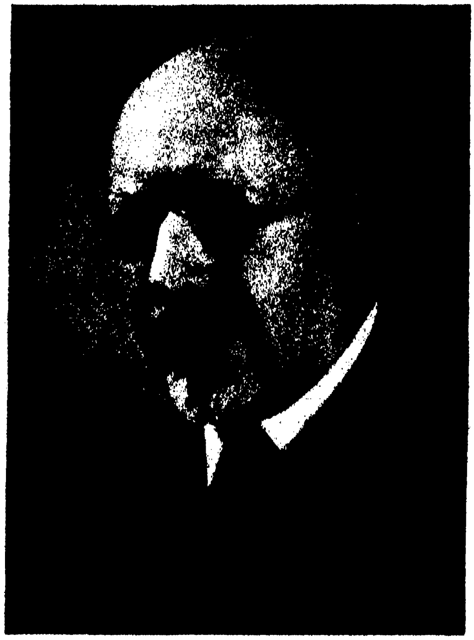
The entire army of the association consists of about 20,000 members. It has 166 allies, technically known as affiliated and associated societies, the total mem-



THE ACCA TEMPLE MOSQUE, WHICH WILL HOUSE THE SCIENCE EXHIBITION AND MANY OF THE SECTIONAL MEETINGS

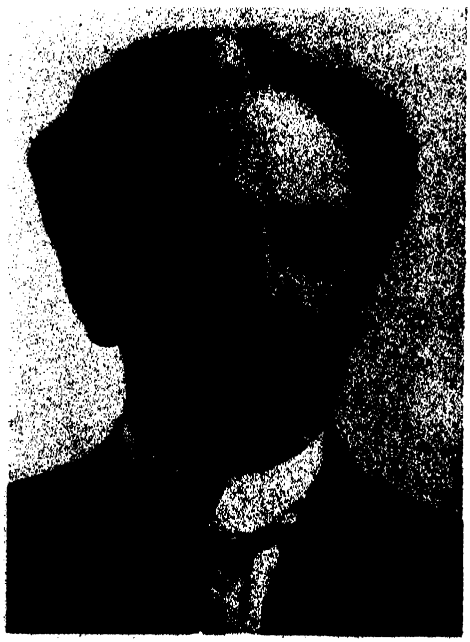


DR. J. R. KLINE
PROFESSOR OF MATHEMATICS, UNIVERSITY OF PENNSYLVANIA; CHAIRMAN FOR MATHEMATICS.



DR. HERBERT E. IVES
PHYSICIST, BELL TELEPHONE LABORATORIES; CHAIRMAN OF THE SECTION ON PHYSICS.

DR. HAROLD C. UREY
PROFESSOR OF CHEMISTRY, COLUMBIA UNIVERSITY; CHAIRMAN OF THE SECTION ON CHEMISTRY.



R. MELDRUM STEWART
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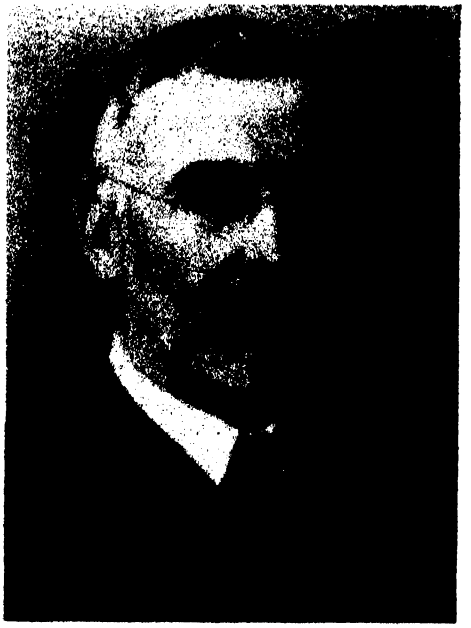
DR. WALTER H. BUCHER

PROFESSOR OF GEOLOGY AND GEOGRAPHY, UNIVERSITY OF CINCINNATI; CHAIRMAN OF THE SECTION ON GEOLOGY AND GEOGRAPHY.



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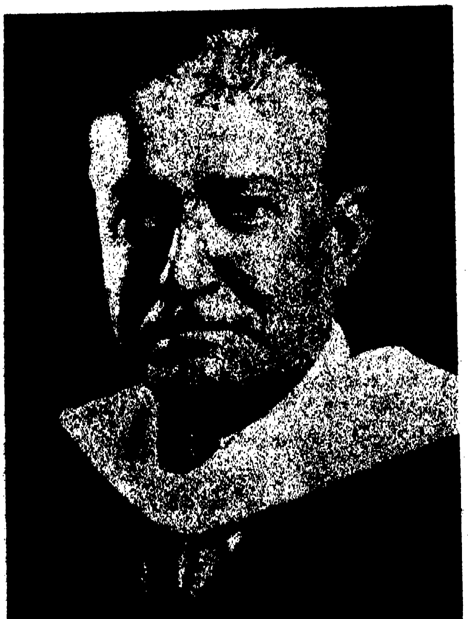
PROFESSOR OF PSYCHOLOGY, UNIVERSITY OF NORTH CAROLINA; CHAIRMAN OF THE SECTION ON PSYCHOLOGY.

HOWARD ROSS TOLLEY
ADMINISTRATOR OF THE UNITED STATES DEPARTMENT OF AGRICULTURE; CHAIRMAN FOR SOCIAL AND ECONOMIC SCIENCES.



DR. NELSON G. McCREA
PROFESSOR OF LATIN LANGUAGES AND LITERATURE, COLUMBIA UNIVERSITY; CHAIRMN FOR HISTORICAL AND PHILOLOGICAL SCIENCES.

DR. A. A. POTTER
DEAN OF ENGINEERING SCHOOL, PURDUE UNIVERSITY; CHAIRMAN OF THE SECTION ON ENGINEERING.

DR. T. M. RIVERS
MEMBER OF ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH; CHAIRMAN OF THE SECTION ON MEDICAL SCIENCES.

ROBERT M. SALTER
PROFESSOR OF AGRONOMY, OHIO STATE UNIVERSITY; CHAIRMAN OF THE SECTION ON AGRICULTURE.

bership of which (including duplicates) numbers several hundred thousand. There are probably altogether about 50,000 different persons in these organizations. The association itself has fifteen different armies or "sections," as they are called, which operate in the following fields: mathematics, physics, chemistry, astronomy, geology and geography, zoological sciences, botanical sciences, anthropology, psychology, social and economic sciences, historical and philological sciences, engineering, medical sciences, agriculture and education. Nothing appears to be overlooked except such arts as music, sculpture, painting, dancing and politics.

Each section, as well as each affiliated and associated society, has its own officers. These officers direct the active work of the association. The chairman of a section, who is also a vice-president of the association, holds office for one year and delivers an address, usually of distinction and wide general interest, at the close of his term. The term of the secretaries of the sections is four years. They do not deliver addresses nor appear in the limelight. They simply work, and if anything goes wrong or falls short of absolute perfection, they are almost certain to hear about it from either above or below, or from both directions. They are much like the Irishman who many years ago wrote to his friend back in the old country, "Pat, come over to this country as soon as you can. All you have to do is to carry the bricks and the mortar up the ladder and the men at the top do all the work."

The general legislative body of the association is the council, which consists of the officers of the sections, either one or two representatives of each affiliated society, depending on the number of its members who are also members of the

DR. GEORGE D. STODDARD
PROFESSOR OF PSYCHOLOGY, STATE UNIVERSITY OF IOWA; CHAIRMAN OF THE SECTION ON EDUCATION.

association, and a number of elected members. The council holds several sessions at each meeting of the association. At its last session in Richmond on Friday, December 30, it will elect a president of the association for 1939. The council elects an executive committee of eleven members with power to act in its place when it is not in session.

It is, however, the chairmen of the sections concerning whom I am writing, for in a sense they are at the head of their respective forces as they drive relentlessly into unexplored regions. In their respective fields they are men of distinction whose researches have made their names known throughout the world. They have received honors and medals, and one of them, Dr. Urey, has been a Nobel Prize winner. Their degrees and present positions are given beneath their respective portraits.

F. R. MOULTON
Permanent Secretary

GEORGE WILLIAM HILL AND JOSIAH WILLARD GIBBS

GREAT men, like lofty mountains, tower most conspicuously above their fellows when they are seen from a distance. In the case of men the distance may be in either space or time. For example, the intellectual eminence of both Hill and Gibbs was recognized from across the Atlantic before it was by those who saw them nearly every day. And from our distance in time we see, as their contemporaries never saw, that in the field of applied mathematics they were giants. On the basis of a few fundamental scientific principles, they outran observations and experiments and erected monumental scientific structures, somewhat as Euclid built geometry on a foundation of a few axioms.

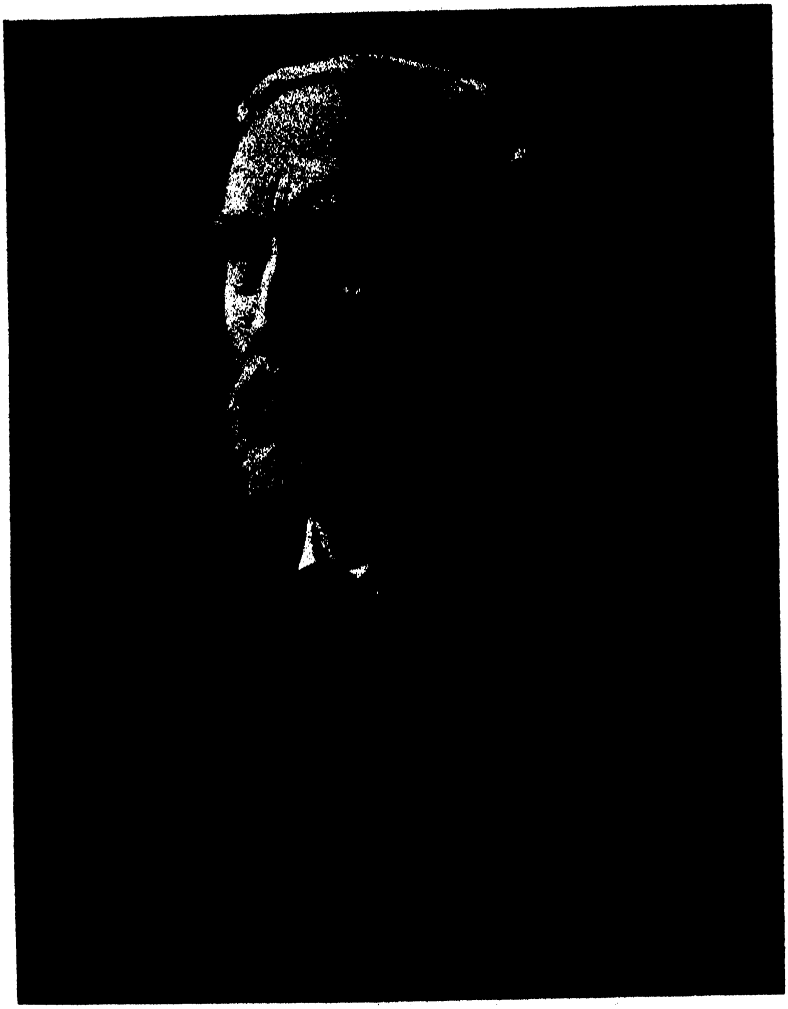
Hill and Gibbs were born about one hundred years ago, the former on March 3, 1838, and the latter on February 11, 1839. During their lives their friends passed the time of day with them or made trite comments on the weather. Their successors now celebrate the hundredth anniversaries of their births. There is, of course, no special appropriateness in selecting the hundredth anniversary for commemorative ceremonies, for the two zeros in 100 are due to the fact that we use ten digits in writing our numbers; with twelve digits what is now 100 would be 84, which would mean eight twelves plus four. The only point of importance is that we are far enough from the lives and work of these great men to see them in excellent perspective. In the light of the progress of science during the fifty or sixty years since they were at the zenith of their powers, we can see how far they advanced beyond their contemporaries. Only recently has the scientific world overtaken them.

The greatest achievements of Hill were in the field of celestial mechanics; those of Gibbs were in the field of ther-

GEORGE WILLIAM HILL

modynamics and what may be roughly described as statistical mechanics. The fundamental principles underlying Hill's work were the laws of motion of physical bodies and the law of gravitation. His tools were the most profound mathematical processes, some of which he invented and developed. The products of his labors were theories of rare esthetic appeal which explained the motions of the heavenly bodies. Such achievements are enough to stir the emotions of the rare spirits who accomplish them, for they demonstrate that we can comprehend the laws of nature and deduce their consequences. And our results enable us to look forward in time, as our telescopes enable us to look outward in space.

The principles on which Gibbs based his theories were the law of the conservation of energy and the laws of thermodynamics. He considered mixtures of molecules in which the numbers of individual units were so great that they could not be individually followed. Yet by ingenious processes he determined their properties in the aggregate and thus proved that in apparent chaos there is essential orderliness. Perhaps some future genius will establish similarly that in the complex domains of our



J. Willard Gibbs

minds and emotions there is also complete orderliness. Experiments have verified the validity of Gibbs's processes and have raised them to the level of precious tools for investigation by those who can use such formidable means for penetrating the unknown.

The Royal Society of London, the Paris Academy of Science and the Belgian Academy felt it an honor to elect Hill to their memberships while he was yet almost unknown in his own country. The Royal Astronomical Society of London awarded him its Gold Medal, and the Petrograd Academy bestowed upon him its Schubert Prize. The Royal Society of London granted him the highest scientific honor in the British Empire, the Copley Medal, and the Paris Academy similarly honored him with its Damoiseau Prize. Columbia and Princeton Universities, Rutgers College and the University of Cambridge (England) granted him honorary degrees. He was

a member of the National Academy of Sciences.

Gibbs also received many honors, first in Europe and then in his own country. He was elected to membership in the Royal Institution of Great Britain, the Royal Society of London, the Bavarian Academy of Sciences, the Dutch Society of Sciences (Haarlem), the Royal Academy of Amsterdam, the Bavarian Academy of Sciences, the Cambridge Philosophical Society, the Royal Prussian Academy of Berlin, the Royal Society of Sciences (Göttingen) and the London Mathematical Society. He also received the Copley Medal from the Royal Society of London, and he was awarded the Rumford Medal by the American Academy of Arts and Sciences. The universities of Erlangen, Christiana and Princeton, as well as Williams College, bestowed upon him honorary degrees. He was a member of the National Academy of Sciences.

What of the families of Hill and Gibbs? Hill was of English and Huguenot descent. His father and his grandfather were artists, apparently in no way distinguished. When he was eight years of age his father moved from New York City to a farm at West Nyack, N. Y., where Hill spent nearly all his life.

Gibbs was of English ancestry and descended from a family distinguished for its scholars. On his father's side there was an unbroken line of six college graduates, five of whom were graduates of Harvard and one a graduate of Yale. Among his mother's ancestors there were two Yale graduates, one of whom, Jonathan Dickinson, was the first president of the College of New Jersey. Gibbs himself was a graduate of Yale and spent the remainder of his life, except for a period of study in France and Germany, as a professor in Yale.

Perhaps nothing in the lives of Hill and Gibbs is more interesting and instructive than their education. Hill graduated at Rutgers College and Gibbs at Yale, as many other boys before and since have done. It is probably safe to assume that they received as much inspiration and acquired as much knowledge from their courses as does the average student. But they both did something that was and is quite exceptional. They read the masters in science. While yet an undergraduate, Hill read carefully such great works as those of Lagrange, Poisson, Laplace, de Pontécoulant, Legendre and Euler, all of whom were French. Gibbs studied the works of Poisson, Cauchy, Fresnel and Clausius. Whether it was the qualities of their minds that drew Hill and Gibbs to the masters or the influence of the masters that inspired them to great achievements we can not know. But at least they understood the masters and took pleasure in following the paths they had trod.

F. R. M.

AN ANCIENT MEXICAN CIVILIZATION

A STADIUM with a seating capacity of at least 8,000, moat-encircled ruins of a town and a towered, twelve-room building are among the remains of an ancient civilization buried in the thick jungles of Campeche in southern Mexico, a land now traversed chiefly by wandering chicle hunters and found in a reconnaissance just reported by archeologists of the Carnegie Institution of Washington.

The party, led by Dr. Karl Ruppert, entered a region of dense forests, hitherto penetrable only with pack mules, by airplane and located the ruins of twelve towns which had flourished long before the discovery of America and, presumably, were built by close relatives of the Maya Indians.

For the most part, these were small places with few substantial buildings. The town in which the stadium stood was an outstanding exception. There was a

level area, about 60 by 70 yards, surrounded by a continuous mound, which was broken in four places for entrances. An examination of the enclosing wall showed that it had been lined on the inner side by a series of from 18 to 20 steps. These constituted the seats of the ancient stadium.

The place was probably used, the archeologists believe, for religious ceremonies and ball games. A game in which a solid rubber ball was bounced back and forth from the hips of the players with the object of getting it through a ring, as in present-day basketball, was very popular among the Mayas, and contests attracted large crowds. The game with many variations, extended northward as far as New Mexico and Arizona, and in central Mexico, had the patronage of the Montezumas. Even in the Mayan heyday, however, the Campeche region was probably bush-league territory. The ruins around the ancient stadium indicated the largest town in the region. The remains of several large buildings were made out, each with elaborate, stucco-decorated façades.

Not far from a little lake in the same general region, the explorers came upon the ruins of another town, now represented only by a few low mounds except for the remains of a single remarkable structure. This latter made up one side of the town plaza. It has twelve large rooms, and three towers—one at either end and one in the center. This last was more than 50 feet high. All the towers were semi-circular and had "false stairways" which were ornamented with great stucco masks. The building might have been roughly similar in appearance to a medieval castle. The moat-encircled town, adding still more to the medieval impression, was a few miles from the same lake in a different direction.

The number of ruins still discernible indicate that the region must have been at one time a flourishing population center. Difficulty of access has deterred previous explorers. The Carnegie party found, however, that several of the mounds had been opened by chicle hunters in search of buried treasure.

Dr. George Stromsvik, of the Carnegie archeological staff, reported the finding of another large ball-court in the ruins of the ancient Mayan city of Copan in Honduras. This was presumably a "big league" bowl where star athletes bumped rubber balls back and forth before cheering crowds more than a thousand years ago. Excavations show that it was the third similar stadium on the same site. It consisted of a long, rectangular playing area bounded on either side by a low, vertically faced bench from which sloping surfaces rose to a second vertical wall. On each wall were mounted three great stone parrot heads. All these heads had fallen down. It has been possible, however, to locate their original bases and they will be replaced. The floor of the playing-court was paved with flat stones. These have been distorted by pressure of tree roots, and it will be necessary to relay them.

Along one wall was found a band of hieroglyphic inscriptions from which it is hoped to find the approximate date when the stadium was built. One incised stone in this band was removed, and the archeologists found on its back another inscription showing that it had been taken from another ball-court on the same site. They found a date which they interpreted as indicating that the old court had been in use for 260 years before it grew too antiquated for the enthusiastic fans of ancient Copan.

THOMAS R. HENRY

THE SCIENTIFIC MO

FEBRUARY, 1939

RELIGION IN SCIEN

By Sir RICHARD GREGORY
EDITOR OF NATURE, 1919–1938
LONDON, ENGLAND

WHATEVER differences of opinion may exist as to the respective fields of religion and science, they meet on common ground in the pursuit of truth and its influence upon human life and conduct. Social ethics are as essential a part of all religious systems as are doctrine and ritual, and their character is determined by both faith and reason. Thus the "Concise Oxford Dictionary" defines religion as "human recognition of superhuman controlling power and especially of a personal God entitled to obedience and the effect of such recognition on conduct and mental attitude"; and the Encyclopaedia Britannica says, "We may define the religious object as sacred, and the corresponding religious attitude as consisting of such manifestation of feeling, thought and action in regard to the sacred as is held to conduce to the welfare of the community or to that of individuals considered as members of the community."

Fifty years ago, the literal interpretation of the Scriptures in the light of modern scientific discovery was the subject of much contentious discussion. Fuller knowledge has shown that the issues then raised were chiefly due to misunderstandings of the meanings of both religion and science. In the sacred writings of the early Hebrews, there are few allusions to what may be termed the rational understanding of the universe or of precise observations such as have been preserved in the records of other ancient peoples. All things were interpreted as testimonies to the wisdom and power of the Almighty and His goodness to man—as subjects of wonder and spiritual exaltation rather than as matters of intellectual inquiry. What is called science or natural philosophy was thus separated from worship of divine attributes. Early Greek philosophers made a similar distinction when they conceived nature as a subject of study apart from religious faith and as a means of discovering natural laws by a methodical application of the human intellect. They were the first to use the word nature to signify this type of objective study.

Christianity is one form of expression of a religious impulse which is universal in human emotional life—primitive or advanced. In common with all religions, its form involves three elements—tradition, ritual and a code of ethics. Tradition teaches the nature of the deity or deities, and conceptions of the earth and man as centers of the universe and life. Ritual prescribes the mode of approach to the deity in a form of worship; and, like the code of ethics, is derived from, and dependent for its character upon, tradition.

With increase of knowledge, modifications of these elements of worship become essential if religious belief is to be a part of progressive human thought

and activities. That such evolution of ideas has occurred is a fact of history, and it may be regarded as the application of discovery, or, from another point of view, as revelation. Only by recognition of this principle can religious forces exert their fullest influence upon intellectual and social activities.

In all primitive religions the earth is regarded as the center of the universe, and the deities as regulating all natural forces, the actions of which might be modified by suitable offerings or sacrifices to the powers controlling them. When Copernicus and Galileo had shown that the earth was only a minor member of a family of planets revolving around the sun, the foundations of all religious beliefs which made it the hub of the visible universe were destroyed, and an entirely new theological structure had to be raised. Newton showed later that the movements of planets and other celestial bodies obeyed a natural law or order, so that it was no longer reasonable to look to them for signs or warnings to the human race. This substitution of permanent natural law for the conception of a world in which all events were believed to be reflections of the moods of benign or angry deities involved a revolution of thought which even now is disturbing to religious beliefs based upon the doctrine of daily supernatural intervention.

Man and Faith

Just as Copernicus deposed the earth from the position it was supposed to occupy in the universe, so Darwin placed man in a new relationship to the rest of living creatures. It is often supposed that Darwinism leaves ethical and moral ideas out of consideration and stands only for the doctrine of "Nature, red in tooth and claw"; but this is due to lack of understanding of the principle. Evolution embodies the idea of social ethics and makes the welfare of the community the essential purpose of the life of the creature. The view that Darwinism signifies nothing more than striving after personal or national mastery at all costs is a crude misconception of this great principle, and was repudiated alike by its founder and by Huxley, its most powerful exponent, as contrary to the best ends of civilization.

Science is concerned with the progress of knowledge and the evolution of man not only in the past but also in the present and future. The idea that such development is possible is relatively modern. The chief philosophers of ancient Greece held that the Golden Age was in the past and that mankind was receding from it; and the same view of human decadence is given Biblical authority in Genesis. It is quite possible that some savages have fallen from a higher to a lower level of savagery, but this is an unusual course to follow. We need not believe that man has degenerated from a state of perfect knowledge to that of being "born in sin and shapen in iniquity," or that the recovery of his lost position must be looked for not in this world but in the next. The adoption of the degradation doctrine is apposed to evolution as a whole and subservient to all progress.

Whether we look to perfection as having been passed long ago or regard it as the promise of the future, the fact that the spirit of man is ever striving to attain it is of particular significance. There is reason for hope when Divine discontent with life as it is urges men to work for higher things. No progress is possible without aspiration, and self-satisfaction therefore signifies stagnation.

Unlike the beasts of the field, man can make his own environment and so promote the development of any type he desires to survive—poet, philosopher, profiteer or pugilist. This is true of man as "nature's insurgent son," con-

tinually fighting against forces of evil which would destroy him, yet able to survive by the use of his intelligence. He may not know the reason for his existence, but he does know that there is law and order in the natural world on which he lives and that if he breaks them the penalty is inevitable. Whether he believes that this world and the whole universe were brought into being by a Supreme Power or not, he has to obey the laws of nature in order to survive. Belief in such a spiritual force may urge him to high endeavor, but upon him is the responsibility of working out his own salvation.

When Napoleon asked Laplace whether he evoked divine intervention in arriving at his theory of the origin of the solar system, the great astronomer and mathematician is said to have answered: "Sire, I have not found this hypothesis necessary." The reply was, however, not made in any spirit of irreverence, for Laplace was a profoundly religious man, as well as an accomplished courtier, and such an answer would have been regarded as offensive by Napoleon who was, at the time, the restorer of French Catholicism. M. Faye, in his book "L'Origine du Monde," says that in previous theories of the system of the universe the calculations had not been pushed far enough, as by them the universe would eventually become disordered. It was, therefore, assumed that, after long periods, there was divine intervention to restore order; and Laplace believed that his theory made such intervention unnecessary. The fact that the theory is not now held to be satisfactory does not mean, however, that a supernatural factor has to be introduced into the calculations in order to complete them.

Belief in the existence of such an omniscient and omnipotent Power behind the Universe is universal. If religion be understood in the broadest sense as the belief in spiritual being, it may be said that prolonged inquiry has failed to show any authenticated instance of a people, however backward, who do not hold to some form of belief, which, though vague and rudimentary, can be deemed religious. It is difficult to draw a hard-and-fast line between magic and religion; and indeed it is a question whether such a differentiation is essential from the point of view of the inquirer who is attempting to trace the development of the religious idea. For even "magic" implies some form of spiritual influence humanly directed. Belief in the efficacy of magic is as much an act of faith in some form of spiritual action as Christian belief in divine intervention in human affairs; and the essence of a religious belief is that it is an act of faith.

Faith may be defined as a belief which is not dependent upon material evidence or logical demonstration from premises ultimately based upon sensory phenomena (although such phenomena may be invoked to support faith as "proof"); but it acquires its validity from some general scheme or theory of the nature and purpose of "being," "life" the universe, or as the philosopher would say, of "the Absolute" or to use a popular phrase, "the scheme of things." In essence it is emotional: not rational. In its contact with "facts" faith interprets them not by observation and experiment, that is, by the approach of reason and science, which demand proof in the strict logical sense, by reference to phenomena, but it evaluates them by the test of coherence with its theory of life and the universe. Such a scheme need not necessarily be consciously formulated or even realized as a whole. Probably, in the early phases of development, such realization rarely, if ever, takes place, as the minds of backward peoples work concretely and are averse from abstraction.

Whatever may be thought of evolutionary faith, evidence from comparative study shows that there is in the mentality of man a generalized urge towards a belief in spiritual values underlying the material appearances of the universe. This urge is fundamental. Various influences such as the influence of geographical and cultural environment, and possibly mental differences of racial strains, if there are such, have combined to produce the different types of belief and the religious systems which have been followed, or are now followed, by mankind. It is at least significant that in the so-called primitive religions of the less advanced cultures there should be such strikingly close similarities in ritual and belief as have been recorded by the anthropologist. Further, when we try to attain an objective view of the more advanced religions, it is no less striking that they fall into a more or less uniform pattern in regard to the relation of the three elements—tradition, ritual and ethics; in other words, in the relation of belief to worship and the conduct of life. Dissension arises not so much out of the nature of tradition as when interpretation is added to it and made a test of orthodoxy. When there is a difference in the central objects of the various cults, opportunities for dissension are multiplied and reconciliation might seem well-nigh impossible. If, however, the spirit of religion is the manifestation of a fundamental urge, recognition of this fundamental unity in man's emotional and spiritual nature should make possible a certain measure of cooperation on a common basis when the aim is the common good of mankind as a whole.

Religion and Life

Many reasons have been put forward to account for the origin of religion, but it can not be said that any of them have solved the problem. Ancestor-worship, ghost-propitiation, worship of the soul, belief in spiritual beings, reverence for tribal leaders, and other causes, have all been suggested as originating causes of religious sentiment. Primitive man had no religion except such as was embodied in a system of social virtues. Men possessing these virtues to a high degree, and using them to make the tribe powerful or conditions of life more pleasant, would be esteemed as benefactors or heroes not only during life but after death, and this veneration would develop into ancestor worship and later into soul worship.

If it is assumed that the divine purpose of the existence and evolution of life upon the earth is that man should work out his own salvation, it is difficult to understand what the ultimate gain will be when the earth will no longer be in a condition to maintain life as we conceive of it. All that science can say as to the future of the earth or any other planet or system in the astronomical universe, is expressed in the words of the hymn, "Our little systems have their day: they have their day and cease to be." We may contemplate the progressive development of man and society to whatever stage which satisfies our ideals, but, so far as we now know, the whole phantasmagoria will eventually be dissolved, and the death of mankind will be the final penalty for achieving the highest type conceived by the human mind. This thought should not, however, be subversive of effort and aspiration on the part of humanity as a whole, any more than the individual should neglect noble motive and conduct because he himself has to pass away whether his influence has been for good or evil. Though science is unable to provide any positive evidence for survival of personality after death, it must acknowledge that belief in such survival is a powerful ethical factor in human development. It is just as permissible, therefore, to assume that

another world awaits habitation of an exalted type of humanity after this earth has come to an end, as it is to believe in the eternal existence of individuality.

Whatever convictions may be held as to the future of man or humanity, the standard of goodness is decided by the community. The man who lives a moral life merely because he wishes to save his own soul is little better than an expectant Hedonist; for his motive is personal profit. He may be saved from punishment hereafter by being negatively evil, but his life will be of no benefit to the human race unless he is positively good. What existence awaits us when we are called away we can not say, but we find stimulus and high endeavor in the hope that each thread of life is intended to contribute to the web designed by its Creator. Though science may not be able to contribute much to the ultimate problems of spiritual beliefs, it does teach that every action carries with it a consequence—not in another world but this—to be felt either by ourselves or others in our own time or the generations to come.

Evidence of the progressive development of forms of life in the past and of changes still going on is so convincing that it may almost be regarded as a law of Nature. In so far, therefore, as evolution signifies an orderly succession of organic growth, few would venture to deny the fact; but how and why such changes are brought about has not yet been established beyond discussion. Whether organic evolution has proceeded by gradual development of small variations of structure and habits or by the sudden appearance of new forms is a question for naturalists to decide among themselves in their search for natural causes. The court of observational science is concerned only with evidence which throws light upon such causes and efforts without assuming the existence of supernatural design or intervention. Whether behind the natural causes producing evolution there is a transcendental principle or architect is not the concern of naturalists but of other philosophers. Their position is that even if the facts of organic evolution can not be explained by existing knowledge, they will be explicable when more is known about natural causes and consequences, without introducing a *deus ex machina* to conceal our ignorance and suppress the pursuit of objective evidence.

We have passed the stage when, in order to afford support for Christian belief in general, and the Mosaic an account of creation in particular, it was only necessary to find naturalistic or rationalistic explanations of miraculous and other elements in Biblical records. Such attempts to fit all new knowledge into a system of thought having no claims to scientific accuracy or intention served no useful purpose to the Bible or to science and to-day would satisfy neither historical students nor naturalists. A much sounder basis can be found by applying evolutionary principles to religious thought and by studying sacred books as steps in the story of man's progressive discovery in theology. It is only by disregarding history that the idea of a fixed and final theology becomes possible. In science, there are no final interpretations or unchangeable hypotheses; and if the same principle were recognized in theology, religion would share some of the vitality of the natural sciences. Evolution can be regarded by the theologian as merely the means of creation; and the conception of gradual development is not incompatible with Christian theology. It is through the acceptance of the idea of evolution in the spirit as well as in the body of man that the partition which formerly separated religion and science is being dissolved.

All religions—primitive and advanced—include ethical ideas relating to the

human conduct and its supreme end. The highest form of religious ethic is that in which the aim of conduct is complete and implicit obedience to a code which is conceived as the will of God. In the less generous manifestations, this obedience may be rendered against natural inclination as an outcome of fear; for "Fear of the Lord is the beginning of wisdom." It may then degenerate into a formalism as lifeless, and even more harsh, than that of those systems which stress ceremonial purity. On the other hand, it may become a joyous and spontaneous acceptance of a mode of life, such as it is conceived would be consonant with the nature of God, subject to such limitations of the flesh as are ineradicable—the idea of saintliness. Hence arises the desire for uprightness as an end in itself, either with a view to reward, if not in this world, in another; or pursued selflessly for its own sake. This concept of religious ethic, which rests ultimately on personal and intimate relationship between the individual soul and its God, has led to the highest idealism in human conduct; but it has also degenerated into many unpleasant forms of exaggerated and distorted continence and self-torture in the monastic, ascetic and mystic conceptions of the holy life.

The aberrations of religious systems of ethics, or rather of their more fanatical followers and exponents, have been pursued in face of the exemplars they had before them, in some instances at least, in the lives and teaching of their founders, such, for example, as Christ, Gautama Buddha and Confucius. These exemplified a practical morality which, had it been adopted by those who came after them, might have served the needs of a united mankind—united, that is, in all that is essential in making for good living and well-being. Such ideal systems, however, it is said, were not adaptable to the conditions of a work-a-day world. But this is true of every measure of reform, and constitutes the justification of its claim to the title of "reform"; while its success lies in the fact that it has forced every-day conditions to comply with its demands, and not that it has adapted itself to them. It has still to be proved by trial that of the ethical systems, which have emerged in the great movements for religious regeneration and revival in the history of the world, no one in its respective field and in some of its more fundamental principles has yet delved sufficiently deep into the elemental constituents of man's nature to attain a rule of conduct, which even such a purist in ethics as Kant might have accepted as law universal.

Since the beginning of the great scientific movement of the nineteenth century, many attempts have been made to comprehend science and religion in one philosophic system. The problem may be approached from two points of view —one of which is based upon naturalistic reasoning and the other upon what may be termed inner reason or faith. Professor Emile Boutroux discussed these different aspects in a valuable volume published thirty years ago.[2] Whatever the relation between religious belief and religious practice, the essential principle in religion is faith in the existence of spiritual powers or action which transcend natural laws and life. To many people, universal belief in such supreme powers is sufficient proof of their reality. There is, of course, a difference between arbitrary belief founded upon spiritual conviction and conclusions derived from verified and verifiable scientific observations and hypotheses; and it is difficult to find a common standard for the two outlooks. Professor Boutroux suggested that they can be reconciled in the ideal of duty or service which summons us beyond the specifically human to a noble struggle and a

2 "Science and Religion in Contemporary Philosophy." 1909.

great hope, an ideal which implies faith and love, and demands a Supreme Being with whom mankind can be in communion. His suggestion may not satisfy the rigorously logical minds of scientific philosophers or theologians; nevertheless, it is in the light of service to high ideals that science, without which we can not live, and religion, without which most people would see no meaning in life, can find a common field for their activities.

Science and Social Ethics

In recent years, there has been much discussion of the ethical or social consequences of the application of mechanical and other scientific discoveries to industry. In the early days of the industrial revolution in England, there was little of the scientific spirit in industry. The discoveries of science were used with as much indifference to science as to humanity. The inventions of the eighteenth and early nineteenth centuries came from the workshop rather than from the scientific laboratory. Machines were devised and operations developed largely by trial-and-error methods, and academic research had few points of contact with industrial practice. The characteristic of the present age is the utilization in industry of principles, properties and products revealed by scientific research whether carried on solely in the pursuit of knowledge or with a practical purpose in mind.

It is sometimes suggested that progressive science and invention are responsible for the troubled condition of the world at the present time, owing largely to overproduction. It would be just as reasonable to blame the Almighty for good harvests or for providing in some parts of the world all the means of existence for primitive man without the need for labor. The fault is not with those who create gifts for men's comfort and enjoyment but with the social system which prevents their easy distribution and use.

National progress must be more striking, more potent to observation than observation in man's ethical and social development; and it is also no more than to be expected that there should be a lag in the latter. It was more than a generation after the initial movement of the industrial revolution in Britain that progress in other directions began to affect the population of the country at large. To any one who takes long views and compares conditions of to-day with those of a hundred to a hundred and fifty years ago it must appear a rash statement which characterizes man's progress in that period as one of command over the material resources of the world only. This is to deny certain patent facts. For example, in every department of human life—at any rate, in Great Britain—there has been in that period a stupendous awakening to a sense of social responsibility—a very real development in man's mentality and the growth of society. In effect it now demands that the latest results of all branches of scientific research, but more especially of those affecting hygiene, both physical and mental, should be applied to the conditions of life of the population as a whole. This is not philanthropy or religion as such in the narrow sense, but arises from a broadening in the conception of the relations and obligations of man to man.

When this movement towards social betterment began more than a hundred years ago, the study of economic and social problems was not envisaged as a matter of scientific research, but in so far as it stood apart from philanthropy, as a question of philosophic principle, as in the doctrines of the Philosophic Radicals, Romilly, Bentham and the Mills, father and son. Some or most of these men were regarded as virtually atheists, but on these questions they were allied

with Quakers and other philanthropic and religious reformers. Bentham's formulation of the ethical basis of conduct and the "end" or purpose of the state as "the greatest good of the greatest number," if a philosophic dogma, at any rate comes as near to being a normative principle in applied social science as was possible in his day.

In alliance with other influences at work in the community at that time, it fostered the sense of responsibility which demanded a more equitable distribution of the wealth derived from the industrial revolution and the introduction of machinery. It is the main theme of the social history of Britain in the nineteenth century—a history covering the crusade against child labor, which was sapping the vitality of the nation, set up by Lord Ashley (Shaftesbury) exactly a hundred years ago, factory legislation, the extension of the franchise, the education acts, the growth of trade unions, the amelioration of conditions affecting wages, hours and surroundings of labor; the after-care of labor in old age pensions and compensation for accident, the medical inspection and feeding of school children—these measures forced on the education authorities by men of science—improvement in school buildings and in housing, prison reform and reform of penal law, in short, a thousand and one social reforms, many of which have been enacted as a direct outcome of the results of scientific research on the conditions inimical or conducive to well-being in human life in the environment of modern civilization. Out of the philosophic and philanthropic ideals of the early nineteenth century there has grown up a vast and practical social science which gathers up and applies the latest results of scientific research in all branches of the circumstances and conditions of life which affect the mind and body of man as an individual and as a member of the state.

Apart, however, from the mental and moral effect, difficult to gauge, of improved conditions of life the increased application of the results of scientific research to those conditions has been accompanied by a parallel growth in the sense of responsibility in the community towards every member of that community—the concept that of the wealth of the community a toll must be taken to ensure that from the cradle to the grave each individual member shall be ensured a certain measure of healthy nourishment, opportunity for growth in body and adequate instruction in mind by education to become a useful member of the community, with assurance of medical attention in employment, a measure of sustenance to the unemployed and of provision for old age.

This is not communism, unless it be communism to admit that I am my brother's keeper; but it is precisely towards this admission that practical application of the modern science of man is directing mankind, both as an inference from the study of societies of the past and the humbler societies of to-day among primitive peoples, as well as from a diagnosis of the elements which appear to make for progress in modern civilization. It is true that a modern society with a sense of responsibility, but which, it must be admitted, we have not yet fully attained, is only now approaching the position of the primitive group in its sense of responsibility to its members. That is perfectly true, but the advance, the spiritual progression, lies in the range of that sense of responsibility. Whereas in the primitive form it embraces the members of the blood kin only, or those of the local group within which the members are more or less intimately acquainted, within a modern society it may reach out to embrace all members of a great nation, and possibly when warring creeds agree to sink their differences, it may extend to all men of

good-will to whom the dignity of man as an individual entity transcends racial and political boundaries. When, if ever, that comes to pass, it will be possible to gauge how far man has advanced along the road of spiritual as well as material progress. To many, the way seems long to go. The urge of nationalism and its ideals has diverted the thoughts of peoples—both fascist and communist—away from the main stream of human progress into narrower channels in which rocks and rapids threaten at every turn to shipwreck all that is best in civilization.

If science has a spiritual message, its function would now seem to be to take a leading part in the process of producing a civilization which will be based upon its service. In the history of early civilizations, a condition of stagnation and of internal dissension has usually preceded their decline and extinction. The end has come through conquest by military forces of a superior type or by the invasion of hordes of barbarians whose only motive was plunder. It used to be suggested that modern civilization would be saved from this fate by the powers with which science has provided civilized peoples to protect themselves against overwhelming numbers having only primitive weapons. The perils which threaten modern civilization are not, however, so much from the greater numbers of peoples who may eventually possess powerful appliances of war as from the very peoples who have themselves perfected such weapons. Efficient barbarity made no distinction in the great war between the destruction of masterpieces of architecture and ammunition dumps; and, since then, aerial bombing of any center of life or of beauty seems to be accepted as a means of offensive action by nations which claim to be civilized. Instead of science having to save modern civilization from being overwhelmed by barbarous hordes, it seems to have provided the means of self-destruction. Man has advanced so little in spiritual evolution that he is just as much a barbarian in his use of aerial bombs and poison gas as he was when his weapons were only clubs and arrows.

Such prostitution of the rich gifts with which modern science has endowed the human race must be condemned by all who see, in the general feelings of civilized people to-day, incipient stages in the development of characteristics which distinguish man from other living creatures. The law of the jungle is that of the battle to the strong, and the race to the swift. It recognizes no right to live except by might; destroys the weak: has no sympathy with suffering: and no sense of the highest human values. In the struggle for existence, man has survived because his physical structure and intelligence have enabled him, individually and in communities, to master the things which would destroy him. His social instincts have at the same time been extended from the family to the tribe, the nation and the empire, and will reach their highest and best when they embrace the world.

The virtues which should be prized most to-day, if civilization is to mean the evolution of social ethics to a noble plane, is regard for spiritual values, love of truth and beauty, righteousness, care for the suffering, sympathy with the oppressed and belief in the brotherhood of man. Any nation or people which separates itself from the rest of the world in the name of race or religion, and cultivates ideals of conquest by force in order to assert its claims, is not assisting human evolution but retarding it. Science has made the world one through the facilities of communications and transport now available; and it recognizes no political or racial boundaries in its fields of knowledge. Among modern social and intellectual forces, science alone speaks in a tongue which meets with uni-

versal understanding. The conception of science as a social factor intimately linked up with human history and human destiny gives a new meaning not only to scientific research but also the position of citizens who are engaged in it. Both rightly and wrongly, science has been blamed for much of the wastage of life which has been brought about by the rapid applications of scientific knowledge to purposes of peace and of war. Men of science are, however, citizens as well as scientific workers; and they are beginning to realize their special responsibilities for securing that the fruits of scientific knowledge are used for human welfare. They can no longer remain indifferent to the social consequences of discovery and invention, or be silent while they are blamed for increasing powers of production of food supplies, providing means of superseding manual labor by machines and discovering substance which can be used for destructive purposes. It would be a betrayal of the scientific movement if scientific workers failed to play an active part in solving the social problems which their contributions to natural knowledge have created.

The view that the sole function of science is the discovery and study of natural facts and principles without regard to the social implications of the knowledge gained can no longer be maintained. It is being widely realized that science can not be divorced from ethics or rightly absolve itself from the human responsibilities in the application of its discoveries to destructive purposes in war or economic disturbances in times of peace. Men of science can no longer stand aside from the social and political questions involved in the structure which has been built up from the materials provided by them and which their discoveries may be used to destroy. It is their duty to assist in the establishment of a rational and harmonious social order out of the welter of human conflict into which the world has been thrown through the release of uncontrolled sources of industrial production and of lethal weapons. By combining exalted spiritual ideals with results of research in the fields of natural knowledge, it is possible now to hope and to expect scientific guidance not only towards individual fitness but also towards a higher human perfection and a condition of social life which will make the world truly a celestial dwelling-place.

NOTE: Sir Richard Gregory delivered lectures upon the subject of this article before the Carnegie Institution of Washington on December 8 and before the American Association for the Advancement of Science on December 29. Sir Richard and Lady Gregory sailed for their home in England on January 5.

MATHEMATICS, THE SCAFFOLDING OF SCIENCE

By Dr. W. F. G. SWANN

DIRECTOR, BARTOL RESEARCH FOUNDATION OF THE FRANKLIN INSTITUTE, SWARTHMORE, PENNSYLVANIA

I SUPPOSE most experimental physicists approach their subject in an attitude which visions nature as governed by certain fixed laws which are unique and fundamental in expression and which are, in fact, independent of our way of thinking about the phenomena. They are then apt to regard mathematics as a means to facilitate the consequences of the manipulations of these laws. It is true that mathematics serves the end in question when that service is demanded of it; but I think we are coming, consciously or unconsciously, more and more to a realization of a more dignified rôle for mathematics. In this rôle, through the richness and complexity of its possibilities of formal relationships, it is able to find in its own structure elements which can be associated with the elements of our intuitive observations in the sense of a one-to-one correspondence, and can build between those elements, often in many ways, a scaffolding of relationship which the physicist ultimately moulds into his mind structure to the end of realizing what he calls an understanding of the phenomena.

Once the laws of a group of phenomena have become moulded into mathematical form in this manner, the physicist proceeds to endow the elements of the mathematical scaffolding with the maximum amount of some vague extraneous attributes which he thinks of as substance and reality. Then, if, as a result of new developments and of advances in our knowledge, it becomes necessary to enrich the mathematical scaffolding, or even to alter it, many feel intuitive difficulty in that they have already placed the seal of their approval upon the old form, have incorporated all their intellectual devotion in it and have dressed it in clothes of reality and substance, which clothes have now become so conspicuous as to seem to be elements essential to the operations of the structure. The mathematical structure itself was a pliable thing, lacking desire to protest against development in its form. While the structure was unclad, none were worried when in the processes of integration of some equation some mathematician said: "Let us change the variable from x to y, where $y = \pi x^{1/4}$". Once the elements of the mathematical structure have been clad in the raiment of substance and reality, however, such changes are apt to disconcert the mind of the experimental physicist, for the clothes he has prepared for the structure which his brain has incorporated will fit no other structure.

Thus, to take a very simple and historical case, the whole essence of what is called the mathematical theory of gravitation is to the effect that a planet moves at each instant in such a manner that its acceleration towards the sun is inversely proportional to the square of its distance therefrom. Immediately this fact is stated, however, the laboratory mind seeks for underlying reasons in which, following analogy with other experiences, it introduces the concept of force emanating from the sun, which force is responsible for the acceleration concerned. The preparation of the mathematical apparatus for the calculation of this force in special cases leads to the concept of a quantity V, the potential, having a value not only at the place where the moving thing is, but everywhere else in space, even though there be nothing there, a

value governed by the well-known equation

$$\nabla^2 V = -4\pi\rho$$

Not liking to leave a dignified quantity like V supported by all the mathematical mechanism of potential theory suspended in the cold of space, without anything to live in, the physicist proceeds to envision some kind of a medium in which V may, as it were, be dissolved with the promise to precipitate itself in the form of its derivatives at any point where substance appears to be acted upon. V is like a spider hiding in its web to do something to every fly which, in the shape of unsuspecting matter, makes its appearance. Directly the medium has been established all sorts of questions are invited, such as those pertaining to what it is made of, what is meant by its existence, and whether it has the same kind of properties as those possessed by other things which have been called media, even though those properties may have nothing whatever to do with the functions of the medium in its purely mathematical sense.

Some of these elements are well exhibited by a contemplation of the classical electromagnetic theory, which visions a number of particles, let us say electrons and certain other things called electric and magnetic fields, all governed by the system of equations

$$\frac{1}{c}\left(\rho u + \frac{\partial E}{\partial t}\right) = \mathrm{curl}\, H \qquad (1)$$

$$\rho = \mathrm{div}\, E \qquad (2)$$

$$-\frac{1}{c}\frac{\partial H}{\partial t} = \mathrm{curl}\, E \qquad (3)$$

$$0 = \mathrm{div}\, H \qquad (4)$$

$$\left(E_i + \frac{[w_i H]}{c}\right) e = \frac{d}{dt}(m w_i) \qquad (5)$$

It is not necessary for me to define everything in these equations. It will suffice to say that they concern themselves with the motions of a group of electrons under their mutual influences. In the customary method of expression of the subject, equations (1) to (4) enable one to calculate certain quantities called electric and magnetic fields E and H in terms of the positions and motions of all the electrons. The process of calculating the motion of any one electron is to calculate at it the electric and magnetic fields in terms of the motions of all the other electrons and then to substitute in equation (5) to obtain the motion of that electron itself, which electron I have called the i^{th} electron. It will readily be seen that there are as many groups of three equations (the three corresponding to the three dimensions in space) as there are particles.

Now, it is perfectly possible to reformulate the content of these equations, so that the final expression of affairs involves nothing about E and H at all; and the solutions of the equations represented by this final state of affairs represent all that anybody ever believed himself concerned with in the classical theory of electrodynamics. What then is the real purpose of the introduction of E and H? I think the answer is to be found in the following: If we wrote down all the differential equations obtained after the elimination of E and H, their forms would have a complexity of structure such as would render it impractical for the mind to coordinate them or, and this is the important point, to see readily and in manipulative form the mathematical properties contained within them. By the introduction of the quantities E and H, we have an intermediary scaffolding. It is true that that scaffolding arose through the medium of intuitive thoughts about electric and magnetic fields which grew up gradually from the birth of the subject; but it could have arisen as the result of a pure mathematical device designed to express the relationships between the motions of the electrons through an intermediary scaffolding which had the power to exhibit in forcible form the characteristic properties of those motions. It is inter-

esting to inquire in what way the intermediary scaffolding performs its functions.

It is well known that solutions of equations (1) to (4) for a charge free region can exist in the form of what we call plane waves; and, for such solutions, the vectors E and H lie of necessity in the planes of the waves and are perpendicular to each other. Although the plane waves exist only in free space, it is easy to see that they can originate through the equations from electronic motions which are possible. It is also easily seen that these plane wave fields, when acting upon other electrons which they encounter, in their passage through space, will, through equation (5), cause them to move also in the plane of the waves, at any rate approximately. In so far as in the old classical theory the phenomenon of the reception of light was supposed to come about by the ultimate motion of some electron in the receiving apparatus, which electron was controlled by the light, we see that the waves of E and H in question have just the mathematical properties to give rise in this electromagnetic picture to a correspondence with what in classical optics was said to be the fact that light vibrations take place in the plane of the wave front, a conclusion demanded by the phenomenon of polarization.

Thus, while in electromagnetic theory—classical theory, that is—it is the motions of the electrons in the source which are responsible for the light, and the motions of the electrons in the receiver which are responsible for the detection of the light, the relationship between these motions which is characteristic of polarization does not make its appearance in a simple form *directly;* but it is very emphatically brought forth by the structure of the intermediary scaffolding involving E and H. The scaffolding is, of course, of our own creation.

I like, in fact, to regard equations (1) to (4) as providing definitions of E and H, which defined quantities are then for use in substitution in (5). One may well protest that he can not discover laws of nature by definition. That is true, but even as a carpenter fashions his own tools to a form suitable to the work he wishes to do, so the mathematician can, through definition, endow the quantities of his structures with properties which anticipate the service which they will be called upon to perform. Herein, I think, lies the reason why, in spite of the complete evaporation in modern quantum theory of that fifth equation concerned with the motion of an electron in a field, equations (1) to (4), which really form, as I have said, the definitions of the vectors E and H, continue to survive. They survive because, being definitions, they can never be discarded on the basis of being wrong. They can only be discarded if the quantities defined are found to have no use.

One may question why I have been so concerned in emphasizing the definitional nature of E and H and have appeared to begrudge them all elements of what the laboratory physicist would like to call their "reality." The reason is that it is those clothes of reality which tend to encumber them with so much which can discredit them. The practical physicist, who "likes to know what he is talking about," will seek a definition in terms of which he can measure H. Somebody tells him that H is to be measured by the force on the unit pole. Of course, a unit pole doesn't exist; but that does not trouble the practical man. He thinks of a long bar of iron which he tells us behaves as though there were magnetic field-producing substances called positive and negative magnetism concentrated at the two ends. He will admit that even in terms of his own concepts as to the logic of things, the points in which the magnetism is concentrated have no meaning except in the light of small volumes which, however, are so large that they contain a very large number of molecules, each of which is itself a little magnet.

This does not worry the laboratory man very much because he says his apparatus is very big compared with molecules, anyhow. That is all very well, however, until in some of the important ramifications of electrodynamics he finds it necessary to talk about the variation of the magnetic field throughout a region which is not only smaller than the region containing his large number of molecules, but is smaller than a single molecule, is smaller than an atom, and is, in fact, an electron itself. Then, of course, I encounter difficulties in some of the fine-grained applications in knowing what is meant by the *force* upon a unit pole. If a physicist tells me that it is the mass times the acceleration, I am worried about the question of what that person means by the mass of an entity which in terms of his own philosophy does not exist; and, I am still more disturbed on seeing a relativist round the corner who, I know, will demand that the mass of the thing which does not exist shall vary with its velocity.

Now, usually the physicist doesn't worry about these matters. He goes ahead with his magnetic and electric fields and makes correctly the calculations of the final quantities which are of concern in his measurements. What kindly guardian angel looks after his mental operations and steers him clear of the troubles I have envisioned? The guardian angel is really a kind of anesthetist who anesthetizes part of his brain to hide from him what he is really doing. He thinks he is using E and H in terms of the definitions provided by his unit poles and the like; but in actuality he is using the kind of E and H that I have envisioned.

There is another aspect of the function performed by such quantities as E and H, and that is the aspect of enrichment of the relationships involved. Before the days of electromagnetic theory we had only electrostatics in electricity; and, if in those days we had spoken of electrons, the theory of their motions would have been of simpler form, and would not, in fact, have conformed to the phenomena of optics at all. There could have been meaning to motions of charges under the mutual influence of electrostatical forces.[1] However, the enrichment of the possibilities of relationships between the motions of the charges secured by the incorporation of the vector H permitted a wider range of possibilities in the relationships in question, a range wide enough to include the phenomena of optics in their story. The electrostatic case still has meaning as a special case of the more general formulation.

We may enrich still further the possibility of relationships between the motions of the charges by incorporation of additional elements in the scaffolding. Thus, it is possible to have relations in which E is replaced by another vector D in equations (1) and (2) but not in equations (3) and (5), while H is replaced by B in equations (3) and (4) and also in (5) but not in equation (1). Such equations are usually referred to as the equations for a material medium because a kind of averaging process of the equations for free space leads to equations of the form in question. However, the point which I wish to emphasize at this stage is that the equations involving these four vectors E, H, B and D, would have meaning as applied to charges in free space; and, would, in fact, constitute, as I have said, an enrichment of the possibilities of these equations.[2] As

[1] I, of course, use the word electrostatics as implying a calculation of the fields of the charges from the same laws as those for charges at rest, even though the charges themselves be moving. I do not wish here to imply by the term electrostatics an absence of motion of the charges.

[2] I must remark that the incorporation of the extra vectors D and B calls for the incorporation of two additional vectorial relations in order to give enough equations to determine the vectors in terms of their charges and of their motions. The elementary form of these relations usually adopted is $B = \mu H$, and $D = kE$. However, the additional relations appropriate to all the considerations involved are more elaborate than this.

a matter of fact, I think it is possible to regard certain comparatively recent generalizations of the older electrodynamics as nothing more than an enrichment of relationships provided by the incorporation of additional vectors in the scaffolding.[3]

Physicists have for the last two or three hundred years sought to explain the actions of those parts of the universe which are not directly observable to their senses through the means of mechanical models. From a mathematical standpoint this amounts to trying to picture the sub-grained universe as governed by the same kind of mathematical laws as the laws which have been found serviceable in the coarse-grained universe perceptible to our senses. In the coarse-grained universe there are things with which mathematics concerns itself, there are springs and weights, there are planets and suns. These things have many attributes other than those which figure in the mathematical relationships concerned with the coarse-grained story of their mutual influences. These things are really irrelevant to that story, but they are often so conspicuous as to leave the unsophisticated with the feeling that the bodies concerned would be meaningless without these attributes.

In the sub-grained universe typified by the universe of the atom, the model analogy leads us again to think of things, electrons, neutrons, and the like. We are willing to forego for these things some of the irrelevant characteristics of the coarse-grained problems of which we seek to make the atom the analogy. Because the earth in going round the sun exhibits, as a result of its motion and the direction of its axis of rotation, the phenomena of seasons with the growth of green fields and flowers at one time of the year and their disappearance at other times of the year, we do not demand that an electron revolving round the nucleus of an atom shall also have green fields and the like upon it. However, the line of demarcation between what we do demand and what we do not demand is not always very clearly marked; and some of the irrelevant elements which are content to stand aside and make no complaint about the lack of call for their services are apt to arise in protest in the naive mind if some condition should arise out of the mathematical reasoning which would seem very disagreeable to these irrelevant properties, in the sense that they could not stand for it in the large-scale things of life. Thus, if in the sub-grained mechanism of some atomic phenomenon it were necessary to imagine one particle to pass right through another, leaving it quite intact, there would probably be protests in the minds of many, concerned with the dictum that two things can not occupy the same place at the same time; and this would be so, even though the laws of the subject which were relevant had no protest to make against this passage of one particle through another.

And so, as I have said, a theory of the atom sought form in a picture in which there were things which moved in accordance with sets of laws something like those of astronomy, and it was hoped that these motions could be regarded as taking place in some all-pervading medium. Physicists are frequently concerned with questions about the reality of things; and, if the kind of model of the atom of which I have spoken had been successful, there would have been the same sort of reason for saying that the particles in it were real as there would for saying that Neptune was real at the time when it had been discovered as being the influence necessary to perturb the planetary motions to their observed forms, but had not been seen. The particles in the atom in these preliminary attempts did have the attributes of large-scale things in the laws which governed their motions. As re-

[3] I refer to Max Born's theory of electrodynamics.

gards the medium to which they supposedly transmitted their story, however, there was even less of intuitive reality. We had become sufficiently sophisticated to avoid requiring of this medium that it should have the characteristics of known media which were irrelevant to its functions. We did not worry ourselves as to whether this medium, this aether, should freeze in the cold of interstellar space and whether, therefore, there should be icebergs of aether floating about. What made the aether seem so very unreal, however, in regard to what were the rather vague conventions as to the standards of reality of the day was the fact that in the things actually relevant to its functions it acted according to laws different from that of any medium with which we were acquainted.

Even with the foregoing concessions in respect of freeing the necessary elements of the atomic world from too many of the embarrassing characteristics which we had been accustomed to associate with reality, it still refused to work properly. The motions of the parts of the atoms didn't do the right things and the aether didn't transmit the story in the right way.

When it appeared that the types of mechanism to which I have referred could not be strained in any reasonable way to tell the story desired, a change in the mode of thinking became inevitable. However, drastic as that change appeared at the time, it was a timid change as we see things to-day. The electrons and so forth in the atom were allowed the prestige of continuing to occupy it and of conforming to some of their rituals of the past, as exemplified by their obedience to the old laws of motion. However, when it became necessary for them to do anything which really mattered, it also became necessary for them to do that thing in a manner governed by no scheme of forces with actions anything like those of our previous pictures. The atom was supposed capable of existing in a number of different states, in each of which it carried out the ritual of the older laws, but did not do anything of importance. It was supposed, however, that a kind of revolution could occur at any time which would convey the atom from one state to another. The story of the revolution itself was not contained in the atom's ritual.

And so, as the development of thought progressed in these directions, models of the atom and the like lost more and more of that naive substantiality which characterized the models of the past. The laws of physics assumed a more and more abstract form. The laboratory physicist became more and more unhappy, and the theoretical man, glorying in an ever-increasing realm of sophistication, talked a language which only he could understand. There was a sort of reversal of simplicity and complexity. The things which were simple in this new era of thought were the abstract laws which controlled atomic processes, and the things which were complicated were the laws of matter in bulk.

In spite of all that may be said, however, for the discarding of models and for the purity of abstract processes, one has to realize that the mind itself is an essential partner in that greater scheme of things which, through the aid of abstract theory, seeks to coordinate, and in this sense understand, the phenomena of nature. In the last analysis, all theories must be moulded to a form in which the brain can respond to them. To attempt anything else is like asking a violin to resonate to electromagnetic waves. Indeed, it is very difficult for the human mind to think at all unless it has something to think about; and he who has discarded models with contempt will probably find, if he is honest with himself, that in his thinking he has replaced these models by other intuitive guides which stimulate his mind to action and which, if absent in one who

listens to him, will leave that one unable to deny, but without conviction, until he has succeeded in growing his own intuitive thought structure in terms of which his brain may function. An intuitive mechanism in the mind functions probably more strongly if one becomes conscious of what it is and what its limitations are; and so it is pertinent to ask what is to replace the intuitive concepts of models in an age which has discarded those models.

Any mathematical physicist who surveys the development of his subject over the past two centuries can not help but be impressed by the survival of the standard mathematical processes of physics through many revolutions in the philosophy in connection with which they are used. Fourier series and their like appear again and again. Those old warriors, the mathematical theorems which express the decisive characteristics of analytic functions, stand immorally ready to serve the needs of any master who is willing to invoke their service. They are like the hired soldiers of days gone by, and even of to-day, willing to fight and sell their own particular form of skill in any cause. The processes of expansion in Fourier series and the like are to be found through many generations of mathematical physics. The fact that the integral of $\sin mx \sin nx$ is equal to zero when taken over a suitably chosen interval when m is not equal to n, and is finite when m equals n, can be regarded as the basis of resonance in the classical dynamics of an undamped vibrating system. A similar kind of property is used again and again. It is this property which, in the guise of resonance, provides for such primitive account of the photoelectric effect as is given by classical theory, and which provides the classical theory of optical dispersion and the like. It is again this property in another form which is the thing which really does the trick in the quantum mechanical theory of the photoelectric effect, and of optical dispersion and the like. It is a similar property of normal functions which becomes the mathematical representative of Bohr's selection principle. The same old mathematical warrior, serving a different master, it is true, and clad in different armor so that he is hardly recognizable in his new rôle, shows his same old metal when he draws the sword for action; for that sword strikes very much in the same way in the old theories as in the new.

It is the existence of product terms involving products of the velocities of two coordinates in the expression for the kinetic energy which, in classical dynamics, provides by the usual mathematical processes for such phenomena as are exemplified in the gyroscope where the velocities associated with one coordinate control the forces which come into action in altering the magnitude of another. It is this fact, the mechanism of whose existence is so pictorially evident to us in the gyroscope which, in equally conclusive mathematical form but with less intuitive appeal, is the origin of the mutual induction of currents in electrodynamics and of the forces between current-carrying circuits. It is this fact which again and again in the modern theories of atomic structure brings about the influence of one coordinate upon another and so reflects the existence of some physical fact.

I have sometimes said that a large part of mathematical physics is concerned with talking about functions in regions where they are analytic in terms of the distances of the point concerned from regions where they are not analytic and in terms of the nature of the abnormality of the function in that region. Thus, we talked about the magnitude of the potential as a function of its distance from a point charge. Mathematically, a point charge is the region where the function ceases to be analytic. This

sort of statement exhibited in the various forms of Green's theorem represents properties of abstract entities, which properties stand ready to be correlated with observable properties in electrodynamics, in hydrodynamics, and so forth. All they need is christening; and once christened they are adopted into the family and made to do their same old work in very much the same kind of way as that in which they have done it before. About all that happens in the transfer of these theorems from one master to another is a change in the form of the heraldic uniform. These uniforms are as a rule unnecessary and are even ofttimes an encumbrance to the duties of the mathematical warrior.

If I were to extrapolate the idea perhaps a little further than I should, I might say that the mathematical physicist, consciously or unconsciously, is like a plumber with various tools shaped to various purposes and well tried for the doing of certain things, because he made them or gradually developed them for such types of jobs. When he comes to some new branch of physics where his services are needed, he pulls out his old tools and tries to find whether the job can be done with them when used perhaps in different ways and in different orders, but always in such a manner that when the story is really told it is a thing which is really characteristic of some particular tool which causes that tool to serve its purpose in the job. If, therefore, we seek aids to intuition after discarding models, I suggest that we seek them in the properties of these tools. For my own part, I have frequently found it of use to transfer my thoughts from a battle between forces and motions in dynamical systems to a battle between mathematical terms and operations, and even to personify these terms and operations. I see a third differential coefficient in the time as something which makes more use of a high-frequency vibration than does a first differential coefficient.

When I look at the familiar old differential equation

$$a_0 x + a_2 \ddot{x} = 0$$

I recognize that it is because its two terms differ by an even number of differentiations that I get a conservation of something in the form

$$\frac{d}{dt}\left[\frac{1}{2}\, a_0 \dot{x}^2 + \frac{1}{2}\, a_2 x^2\right] = 0.$$

I realize that when the original equation is generalized to the form

$$a_0 x + a_1 \dot{x} + a_2 \ddot{x} = 0,$$

it gives lack of conservation in showing that

$$\frac{d}{dt}\left[\frac{1}{2}\, a_0 x^2 + \frac{1}{2}\, a_2 \dot{x}^2\right] = -a_1 \dot{x}^2,$$

where the lack of conservation is symbolized by a right-hand side being always of one sign.

I observe that if I write down the still more general equation,

$$a_0 x + a_1 \dot{x} + a_2 \ddot{x} + a_3 \dddot{x} + a_4 \ddddot{x} + -- = 0,$$

and multiply all the way through by $\dot{x}$, I can integrate all the terms involving even orders in the differential coefficients so as to represent them in the form of d/dt of something; and this is because at each operation one of the members of the product of two derivatives increases in order by one, while its companion decreases in order by one, so that the two approach each other in order by two and eventually integrate out. On the other hand, the terms involving originally only odd orders must of necessity grind down on integration by parts to something which is the integral of a square and so they lead to lack of conservation. And so, I regard my odd power terms as dissipators, and keep them carefully in mind as such in introducing them as soldiers in the fray.

And so I would agree with the lamentations of him who, in the discard of mechanical models, finds it difficult to pin upon something to think about, and would suggest that in his mind he re-

places the battles between forces, inertia, and the like, with battles between mathematical terms, functions and derivatives, endowing some of these conceptions with sorts of personalities, and choosing as the basis of their incorporation in theories the purposes immediately to be served.

It is by no means visionary to hope that one may adjust his intuitions so as to work with realms of concepts other than those with which our immediate predecessors have worked. A mechanical explanation of things in the ordinary sense of the word was by no means an intuitively satisfying explanation before the time of Galileo. However, those of us who were born in the late Victorian era were bred on the old mechanics, and the custom was to try to see all new phenomena in the light of a mechanical picture. Thus, when in my youth anybody wished to try and make me understand how it came about that an electrical circuit composed of a condensor, an inductance and a resistance, in series could oscillate, he would call attention to a weight vibrating in oil, at the end of a spring and would say: "This thing L, a self-inductance, in the electrical problem is like the mass m, of the weight. The resistance R, to the flow of the electric current, is like the resistance r, offered by the oil. The condensor in the electrical problem performs the function of the spring in the mechanical one. By thinking of the weight, spring and oil, I hope you will understand why the electrical circuit oscillates." Now, to show that the mechanical concepts have no *a priori* right to intuitive fundamentality, I may remark that to-day the youngsters start to play with radios before they go to college, so that they meet electrical circuits before they meet springs and weights in their mechanics classes. Perhaps the situation with you is like what, from a well-known professor of electrical engineering, I have learned it to be with some of his students in these days. Perhaps you understand electricity better than you understand dynamics. Perhaps I should have started with electricity and now say to you: "From your knowledge of electricity I will proceed to explain why it is that a weight tied to one end of a spring and hung in oil bobs up and down in the way it does. Now, you all know that if you have in a radio circuit composed of a self-inductance L, a resistance R and a condensor C, it will, under suitable conditions, oscillate. If stimulated by an external radio wave, it will build up an oscillatory current which is greater the greater the degree of tuning, etc., etc. Now, I want you to think of this weight as something like the self-inductance, this oil as something like the source of electrical resistance in the wire, and so forth. I hope that by drawing upon your knowledge of how an electrical circuit oscillates, you will be able to appreciate why and how a weight bobs up and down on the end of a spring."

I think that the physicist would gain by incorporating to a greater extent than he does the mathematical mechanisms, as I may call them, into his intuitions, by endowing the mathematical processes with the same degree of intuitive satisfaction as that formerly accorded to his models and with a more clear recognition of the correspondence between the mathematical operations and the physical facts.

I may illustrate my meaning by referring to a statement customarily used in connection with the restricted theory of relativity to the effect that similar experiments performed upon systems moving with relative constant velocity give identical results. To me the doing of similar experiments has absolutely no meaning without further clarification. Thus, if I simply take the words at their face value, I might say that I was doing similar experiments upon the two systems if, standing on each of them successively, I measured the wave-length of the sodium D line emitted by some star. In this case, however, as every one knows, I should obtain different re-

sults, the difference being, for the most part, an exemplification of the well-known Doppler effect. Of course, the relativist would tell me that I had not done the same experiment, and if I asked why, he would tell me that in each system I ought to have my own star to move along with me; but I am left a little dissatisfied until I inquire further into the matter and, that in this matter I am not the only fool in the universe, there is the evidence that again and again this Doppler effect is cited by those who do not quite understand the theory of relativity as an objection to it. What then is the solution of the matter?

When the mathematician considers a set of differential equations he is apt to speak of the conditions which must be specified in order that the set shall have a unique solution. He refers to the fact that it is necessary to assign a certain number of quantities in addition to the differential equation in order that the complete story shall be told. Thus, in classical astronomy, the orbits of the planets are uniquely defined, as are the motions in those orbits, by the assignment of the positions and momenta at some instant. I like to regard the doing of an experiment as the fixing of those quantities which it is necessary to fix in order that the differential equations of the subject shall have a unique solution. The meaning, then, of doing the same experiment in two different systems is the assignment of equal numerical values to the corresponding quantities which determine the solution. The doing of two similar experiments would be meaningless were the equations for the two systems of different order, for example.

I have said that in classical astronomy the planetary motions are determined by the assignment of the positions and momenta at some time. This is because the equations are of the second order. Had they been of the third order, the assignment of mere positions and momenta would have left an ambiguity in the solution; and, had there been a physicist who thought the equations were of the second order when they were really of the third, he would have come to the conclusion that doing what he called the same experiment twice over would in general give different results. He might even formulate a principle of indetermination as a result. Indeed, this matter has a bearing upon the so-called principle of indetermination in atomic structure; but of that I will not speak now.

The higher the order of the differential equations and the greater their number, the less they say, and the more is left to be said by the supplementary initial or boundary conditions. The beginner in relativity theory, having encountered much difficulty in building up equations which are invariant in the restricted theory, is astounded when he hears the general theory talking of relations which are invariant under *all* transformations of coordinates. The equations of the general theory acquire this apparently remarkable property by the characteristic of saying less than those of the restricted theory, leaving more of the story to be told in the boundary conditions. By saying sufficiently little it is possible to increase the generality of truth of that which is said. Indeed, it is obvious, for example, that if a differential equation should be of infinite order, it would say nothing, which is a sufficiently non-compromising statement to be invariant under all transformations of coordinates.

The general theory of relativity provides a good illustration of how the facts of nature may be connected in all sorts of different ways, each of which is capable of giving rise to a different set of intuitive concepts. The nature of the intuitive concepts is, in fact, determined largely by the types of coordinates chosen. Thus, for example, if I represent the story of planetary motion in terms of a suitable system of coordinates, the restrictions upon the problem engendered by that choice throw the laws

into a form in which the story is told in terms of equations in which there are, for the most part, accelerations on the left-hand side and functions of the position on the right, so that out of this picture can be grown the old intuitive concept of forces and the like. If I choose other sets of coordinates the story must be told in another way as regards any intuitive concepts with which one may accompany it.

If I were asked to express in very brief popular form the essential thing which is accomplished in the general theory of relativity, I do not think I should talk much of curved spaces, and the like, but should give the following analogy:

Suppose an investigator should be sent into a country to investigate the laws of the country. Let us suppose that he was a rabid non-smoker, an absolute teetotaler and endowed with the plague of rheumatism. He brings back his report to me. He gives me a very concise and beautiful statement of the parliamentary procedure, except that in it I find woven into the description long discourses upon the unhealthiness of the atmosphere and the impossibility of correct judgment being formed in it which I ultimately conclude arose from his having observed somebody smoking during the deliberations. A similar situation may exist with regard to matters pertaining to strong drink, and he may imply that the variations of humidity of the conference rooms are totally abnormal in relation to what it seems they should be from other matter in his report.

When I read this report, I shall come to the conclusion that it consists of two parts woven together, something depending upon what was really happening in the country, and something depending upon the idiosyncrasies of my investigator. Of course, if I knew those idiosyncrasies I might make due allowance for them, but I should always be a little uncertain because, after all, they really might have a very vile brand of cigar in that country. The best thing I could really do would be to send into the country a whole army of investigators with all sorts of idiosyncrasies and accept only that which they all agreed upon.

Now, when we formulate the laws of nature, many interesting things present themselves. In the old days we thought that they were all fundamentally characteristic of nature, but the ultimate philosophy which we have been driven to by the theory of relativity leads us to the belief that some of these interesting things are really inherent in nature herself, and some of them are a consequence of the way in which we have made our measurements. These latter things may be also very interesting to us, as interesting as was the effect of the change of climate on the rheumatism of the investigator cited above. However, it is important to be able to separate the consequences of our two observations into these two categories—those which are fundamental and those which are inherent in our measurements. You may say, why separate them? Perhaps the answer is, that any extension of knowledge results from meditation upon the implications of the laws of nature as we see them, and it is only worth while to meditate upon the parts which are significant. It may be of great value to meditate upon the governmental structure of that country to which I referred as regards its potentiality for war and the like; but it will be of little international value to meditate upon my own rheumatism, however important that may be to me.

To come now a little nearer to the actual procedures involved, I may say that all our information about nature is obtained from our measurements. We may fix the collision of a comet and a planet by measuring the distances X, Y, Z, north, west and up of, let us say, Washington, and the time T at which the collision occurs. We may fix the

event in another manner. We may measure certain angles with telescopes. I must not pursue this too far into its detailed ramifications. Let it suffice to say that it is as a result of such measurements, and in terms of them, that we express the laws we find. Now the relativist sets out to find how much of what he expresses in this way is independent of the particular ways in which he makes the measurements. That part is inherent in nature. The great elements of skill involved in his mathematical procedures are involved in his finding out how to say—in mathematical equations—these absolute facts about nature in such a way that, if he should tell the story in terms of other types of measurement, the ultimate story would be the same.

In spite of all the discredit that modern science has thrown upon the intuitive concept of reality, you may maintain that you can not escape the very emphatic consciousness of the substance of things. You will tell me that when you bang your head against a wall, it seems most emphatically evident that there is reality in the wall and that the wall is there. You will protest that all things are not shadows. You will tell me that you can touch things, you can feel things, and that deep down in your very bones you believe that they are there. I sympathize with your feelings, but I must warn you that all you have as your criterion for the existence of whatever it may be that you are thinking about, all you have for your criterion for the existence of the reality of this "substance," is the set of impressions you get from your senses; and the abstract principles of science will, if they have been properly chosen, reincarnate in the approximate and crude form of your senses that concept of reality with which you started, and which seemed so very substantial and meaningful to you. They will construct this reality, not with simplicity, but with the appropriate complexity which should adorn it. I fear there will be many things about it of which you will feel rather ashamed; but humbled in its reincarnation, it will nevertheless be sure of the ground left to it.

And so we begin to see that, in line with the spirit of this philosophy, there is an artificiality in the old reality, and a true reality in the new artificiality. The new reality is not a development of an enhancement of the principles of the old; but the old is rather a rickety, somewhat illogical, vague and incomplete structure which comes nearest to respectable form when reincarnated out of the principles of the new.

If, in spite of all I have said, you still seek to prune your own concepts into something which, over the whole realm of nature, has those elements of reality desired by your primitive senses, then I fear you are doomed to disappointment. At best, you are doomed to the life of one who seeks an ideal which becomes more and more remote as he continues to pursue it. Like the moon, the ideal will always seem to lie behind the mountain ahead; or like the rainbow which seems to descend to the earth at some definite spot, it will move away from you as you approach the spot where it seemed to be. It is said that God fashioned man in His own image; but it is very evident that it is man who has fashioned God in his image. If, in your search for that which the imp in your soul has told you is final and which is reality, you should beguile some sorcerer to bring your ideal to you for a moment for your inspection, you will see but the image of your own face in the picture. You will see the mechanism of that thing which was the old reality fighting like an octopus to find holds for its tentacles upon the true realities of nature; and as you examine more closely the form and actions of that octopus you will find that it is none other than your own brain.

SOME PHILOSOPHICAL REFLECTIONS OF A BIOLOGIST. II*

By Dr. R. E. COKER

PROFESSOR OF ZOOLOGY, UNIVERSITY OF NORTH CAROLINA

A BIOLOGICAL PRINCIPLE OF UNCERTAINTY

There is another phase of the problem which merits consideration. It is a well-known fact that protoplasm has never been completely analyzed chemically. We start in the laboratory with dead protoplasm, of course, but inasmuch as there is no loss in weight in passing from the living to the dead state, it is to be assumed that every chemical component of the living is present in the dead protoplasm. As every one knows, however, it is not the number of chemicals or their weights which gives character to protoplasm; it is the *organization* of the substance that is the essence of life, chemically or biologically speaking. Now to what extent is it practically or theoretically possible to ascertain the precise nature of that organization? It is, of course, a fundamental character of living protoplasm that it is a dynamic system, that it is not characteristically at rest, but is always in process of change. This fact alone complicates the problem of a satisfactory chemical analysis; but let us look a little further. If "life is response," if protoplasmic activity is interaction between protoplasm and environment, or rather between protoplasm and *change in the environment* (stimulus), what is the logical conclusion as to the possibility of reducing biological activity to a chemical formula with proper mathematical dressing? There seems to be no possibility of beginning to attack the living organization of the molecule of protoplasm, without bringing about responsive change in the protoplasm.

"... we must remember," says Niels Bohr ("Atomic Theory and the Description of Nature," 1934), "that the investigation of the phenomena of life not only leads us, as emphasized in the article, into that domain of atomic theory where the usual idealization of a sharp distinction between phenomena and their observation breaks down, but that, in addition, there is set a fundamental limit to the analysis of the phenomena of life in terms of physical concepts, since the interference necessitated by an observation which would be as complete as possible from the point of view of the atomic theory would cause the death of the organism. In other words: *the strict application of those concepts which are adapted to our description of inanimate nature might stand in a relationship of exclusion to the consideration of the laws of the phenomena of life*" (pp. 22–23).[3]

Physicists tell us that it is impossible to determine with complete accuracy both the location and the velocity of movement of a particle at the same time, because any effort at measurement will inevitably involve either a change in the velocity or in the location. The same paradox seems to confront us with reference to protoplasmic behavior. There seems to be no conceivable possibility of ascertaining the nature of protoplasm at any given moment, in view of the fact that any attempt at investigation involves a change in the environment which either destroys the organization

* Concluded from the January issue.

[3] I am indebted to Dr. Arthur E. Ruark for reference to Bohr's book, which was read after the preceding and following paragraphs had been written.

or which at best may be responded to by a change of organization. The impossibility arises from different conditions in the two cases—or does it? In the case of the electron, we are debarred from measurement for lack of a measuring rod of sufficient delicacy to avoid disturbance of the object to be measured, or because the instrument itself may be changed in the act of application.

The same statement could be made with reference to protoplasm, but the difficulty is perhaps due not only to the relative coarseness of the implements we must employ, but also to the inherent sensitivity of the object to be measured. Its sensitivity is the condition of its being the object of measurement, that is, of its being living protoplasm. Biology has its own "principle of uncertainty" in that there seems to be no theoretical possibility of determining precisely the nature of organization in a system which of its own inherent nature changes its organization every time we make any attempt to inquire into that organization. I think we might even say that the protoplasmic complex changes its organization *defensively* (and perhaps offensively as well) with every attack upon it. Should any one question the propriety of the term "defensively," let judgment be deferred until we have arrived at a later paragraph. It seems safe to say, at least, that there can be no ultimate solution of the problem of determining the organization of vital substance until we find a means of attack to which the substance is not responsive. At present that seems to spell a logical impossibility.

My vision of the future encompasses no conceivable state of biological and chemical science when all or any biological phenomenon will be reduced to chemical and physical terms. Rather, I envision an eternal game of battledore and shuttlecock between biologists and chemists. Repeatedly, the biologist must say to the chemist or physicist, "I have carried my investigation to the point beyond which I can not go by methods available to me; now you take it as a problem of biochemistry." I contemplate also that after a time the chemist or the physicist will have to say, "I have made my contribution and have arrived at a point beyond which chemical or physical methods will not avail. I pass it back to you for a while." And so it may go. We seem to forecast eternal cooperation in a task without end!

The contemplation of an endless task may offer discouragement to some persons. To such it can only be said: If you are made of the stuff that can find encouragement and hope only in the expectation that the task to which you have set yourself will ultimately be entirely completed, with nothing left to be done by those who come after, it is perhaps better that you should keep out of biological science—or any science; and perhaps I should add also, keep out of philosophy. Look for peace of mind in some more lowly undertaking.

A Biological Principle of Relativity

The recognition of life as interaction between protoplasm and environment seems to lead us inevitably to what may well be called the Biological Principle of Relativity: we learn absolutely nothing about how an organism or a cell lives except as it behaves in relation to something else. This seems so obvious that I need take little time to discuss it. The relativity of all knowledge is such an old philosophical concept that the novitiate in philosophy would be presumptuous in attempting its exposition. Nevertheless, one may be permitted to try, even at the risk of being somewhat trite, to show how the biologist arrives, and seemingly must arrive, at his own principle of biological relativity.

If the biologist is to deal with life, he must first ask himself how he can distinguish living from non-living things. Without discussing all the tests that may

suggest themselves, we can say that the most generally applicable practical criterion is this: that living substance responds to a stimulus by an adaptive response. It should perhaps be explained here that the biologist uses the expression adaptive in a specialized sense, or perhaps in two senses. Like every one else, he calls it "adaptive" when an organism does the fit and proper thing in the circumstances presented, as when a wren, finding no hollow tree handy, makes its nest in a tomato tin tacked onto a post. Again, on the other hand, the biologist uses the word "adaptive" as almost synonymous with "responsive"—perhaps on the theoretical assumption that the response will be of a nature that will in the majority of cases, but not necessarily in all, be useful or adaptive in the ordinary sense. Jumping from the frying pan into the fire is only one illustration. There is presumably no particular advantage in being broiled rather than fried, or vice versa indeed, but it is a good general rule to go somewhere else when it gets too hot where you are. There are cases too, in which a directly suicidal act is a service, not to the individual but to the species.

After this digression let us return to the consideration of our practical criterion of life: living substance responds to a stimulus by an adaptive response—not just any response, but one that is adaptive, meaning one that has some relation to the welfare of the living substance. Then, if we ask what is a stimulus, we have to say that it is an appropriate change in the environment—not just any change, but one that leads living things to give an adaptive response. To test its viability one puts an egg in an incubator; had it been placed in cool moist soil and failed to develop we should not have regarded it as a bad egg. On the other hand, one puts an acorn in moist soil rather than in a dry incubator. We must find the right stimulus in each case. Obviously, we are getting into another circle. A living thing is something which responds adaptively to the sort of thing that will make the living thing respond adaptively. We had as well say: a living thing is something that acts like a living thing!

It comes back to the significance of "adaptive response." I think that we can properly say that a living thing is something that tends to look after itself or its kind, something that tends to meet the world, not passively, but both defensively and acquisitively. It tends not only to resist the destructive or encroaching pressure of outside objects but also to use such objects to promote itself or its kind. It tends to grow and to multiply, not for itself alone, but for the promotion and increase of its kind, even though for the production of its kind it must sacrifice some part or the whole of itself. Personal sacrifice, by the way, is not an exclusive characteristic of man or of life at any particular level. The worker bees that give up all capacity for self-propagation to spend their entire lives in the protection, feeding and nursing of the larvae and of the queen, the one reproductive member of the colony; the drone bee that sacrifices his life in the mating process; the paramecium that divides into two; the tiger that goes into battle for its young; the plant or animal that gives off ova, pollen or sperm; the seed that sprouts and so hastens the end of its own individual existence; the man that lays down his life for country or principle— these are all obeying the same law of nature. It is not necessary to assume that all such acts are done by intention; it is enough to observe that it is in the very nature of life that these things are done.[4]

[4] The "Bible of Nature" may not be an altogether inappropriate term, since one can find in nature support for all kinds of social theories, by the simple device of picking out particular natural phenomena and disregarding the context. It does seem, however, that the very least

"Self-preservation is the first law of nature." That, indeed, is a very crude and inaccurate statement. "The preservation of the kind is the first law of living nature" would more nearly fit the facts of biology. The ecologist would indeed go farther, conceiving of neither the individual nor the species as the ultimate value. Both paleontology and everyday ecology show that nature sacrifices the species to the good of the community as a whole, with the same equanimity as she displays in sacrificing the individual to the good of the species. That is something to give mankind pause—if anything can. I should say, however, that the first principle of biology is that there is within living substance a condition of internal pressure, tending toward expansion of self or kind; call that pressure by a fancy name if you will. Perhaps the chemist would say that we have in protoplasm a highly complex chemical system that is never in equilibrium, that has always unsatisfied bonds. I do not know just how the chemist is to express the broader manifestations of this instability of equilibrium—this universal tendency to bring about equilibrium, and therefore death, in some units that others may continue in a state of activity.

Assuming that we know anything, it seems to me that one thing we know is that we can not know anything except with reference to something else, that all the knowledge we have is relative. That being the situation, we can not expect to reach an ultimate and complete solution of any question that is presented to us, and it does not seem to require a great deal of scientific or philosophic discussion to establish the fact, if facts have any value to us. What the physicists have done recently is to demonstrate experimentally and theoretically that this is a scientific truth with reference to the movement of electrons. That I should take to be an important contribution to physical science, and a discovery of great interest to philosophy and scientists in other fields.[5] It may perhaps serve to remove the foundations from some of the cruder doctrines of mechanism. It does not, however, undermine mechanism completely, and, as far as I am capable of judging from what little I have heard or read, it does not even establish or weaken the doctrine of free will: regarding these two conflicting ideas, we are left where we always were and where presumably we shall always be, since the answers to these questions seem to lie without the circle in which we have to live and move and have our being.

It does appear that a great deal of useless speculation may be avoided if we could regularly recognize some simple facts about how knowledge is gained. I have heard speculation on the question of whether, if we know everything about free hydrogen and everything about free oxygen, we could necessarily predict that the union of these two elements in proper proportion would give us a substance with the qualities of water. Ap-

evidence is available to support either extreme of individualism—the one that says: "Every man for himself and the devil take the hindmost"; and the other that would make the interest of the least efficient paramount, and—devil take the foremost! Organic nature does not seem to work in either of these ways. After alluding to the oft-emphasized competitive struggle of animals for food, water and safety, Allee remarks: "It is only lately that equally plain evidence has been massed to show that animals cooperate usually as unconsciously as they compete to secure these same necessities." At the risk of incurring criticism for choosing a text from nature and applying it to human affairs, I may give personal endorsement to the familiar view that that portion of mankind will best survive that shows capacity for the most genuine and intelligent cooperative effort.

[5] Since this was written and presented orally, a paper by Dr. Harold Jeffreys, entitled "Science, Logic and Philosophy" has appeared in *Nature* (141: 672–676 and 716–719, 1938). "The Heisenberg uncertainty," he says, "is no new discovery in principle, but an estimate of a lower limit to the old uncertainty which was never neglected except by misplaced optimism."

parently, the conception of "emergent evolution" is based in part, at least, upon the assumption of a negative answer to questions such as the one just stated. It is with no little diffidence or sense of temerity that I frankly express my whole-hearted conviction that there is hardly a better example in our language of the drowning of thought in a sea of words. All that we know about hydrogen is relative to something else; and we can know nothing of oxygen except in its relation to other things. When one reads this statement: "We do not arrive logically at water by studying hydrogen and oxygen," the question may well come to mind: Do we on the other hand arrive logically at hydrogen or oxygen without studying water? After we have absorbed this profound statement and the equally profound responsive query, where have we gotten? Exactly nowhere! Emergent evolution merely brings us back to the principle of relativity in thought just as an earlier discussion seems to lead us to the conclusion that life itself is relative. Wherein is one discovery of fact, or one change of kind, any more "emergent" than any other?

Vitalism, Mechanism or Neither

A little while back it was suggested that some of my remarks might lead me to be branded as a vitalist in the metaphysical sense of Driesch and others. The tag is emphatically disclaimed because I conceive of nothing more futile than an argument over whether the vitalist or the mechanist has a truer idea of the meaning of life. To my mind, and I admit its deficiencies, the vitalist is merely one who closes his mind against all but one side of the picture, and similarly the mechanist is one who refuses to look at the plain facts that loom so large in the mind of the vitalist. It seems to be a very simple task for the vitalist to take the well-known facts of embryology and so to apply them as completely to demolish pure mechanism. Apparently it is just as easy for a mechanist to blast the underpinnings out from beneath the position of the vitalist by showing the vanity of any attack upon biological problems from a purely vitalistic base. Superficially the mechanist seems to be in a little better position, because he can go on being a laboratory biologist, while a vitalist, if "deeply convicted," so to speak, must lose hope of even a fair measure of progress in the pursuit of biological science. It is, I am sure, not just a coincidence that the leading exponent of the alleged principle of vitalism abandoned biology for a seat in the sanctum of a sister discipline—philosophy; nor is it strange that the most outspoken mechanists seem generally to be those who in their work have least to do with living beings as such.

Now I fully realize the position of embarrassment in which one may seem to place oneself if, with two seemingly mutually exclusive hypotheses, one does not choose between them. It might be said that this shows a lack of decision or of courage. But we do not have to choose between supposed alternatives until we know what they are and whether or not they actually are mutually exclusive. The difficulty is in the lack of acceptable definitions. Just what is meant by mechanism? In one sense it seems to relate to machinery, but I know of no machinery which is not conditioned upon some sort of protoplasmic activity. If it means merely that biological phenomena are reducible to chemical and physical terms, the first and perhaps the weakest answer has already been given, namely, that no biological phenomenon has yet been reduced to chemical terms. How could it be, when the protein molecule plays such a part in protoplasmic behavior and not even the structure of one protein is yet known?

The second answer is that I am not

sure that chemical and physical principles have yet reached the stage when we can properly appraise their theoretical applicability to biological phenomena. When the physical scientists, starting out with clearly non-living materials, can give us even the rudiment of a working system that will grow and reproduce, behave and misbehave, like an organism, it will be time enough to take notice of the claim that biological phenomena are special cases of physical chemistry *and nothing more.* Such a statement should not, of course, be taken to mean more than it says. The scientific spirit is not tolerant of assertions that this or that can never be done. One recalls the story of the mathematician who demonstrated conclusively that a baseball could not be thrown to describe a curve. Is it in his honor that the modern spectators rise to their feet in the seventh inning? To say that living phenomena are not explicable in terms of present-day chemistry and physics is to utter a truism. To say that they can never be explained (or that they can be explained) in terms of future chemistry and physics is to make unwarranted assumptions as to what the chemistry and the physics of the future will be.

"Bridging the gap" between living and non-living substance may well command the keenest interest and the most capable effort. Abiogenesis, or "spontaneous generation," as an article of faith and a beam of hope, has arisen more than once in the past—only to fall as often as it has arisen. It may well rise again—it must arise, one might think—and it may fall—who knows? It may be an aid to clarification in thought if one recalls Preyer's three categories: *biosis,* with continuing display of life; *abiosis,* destruction of the organization bringing actual death; and *anabiosis,* referring to suspension of living activity without fatal disorganization, as with the dried tardigrades which "came to life" after years of apparent death. Abiogenesis, actual gap-bridging, seems to involve a start from clearly non-living material rather than from originally known living material which has been so modified as to seem for a period, and until a proper change of conditions, non-living.

On the other hand, before we flee from the mechanistic stronghold into the camp of the vitalist, let it be observed that the vitalist admittedly knows nothing about the so-called vitalistic principle, and even boasts that he can know nothing about it. Obviously then, it is not a biological or scientific principle, but a philosophical one, if it is a principle of any kind.

One speaks only for oneself. Another may find it agreeable and helpful to proclaim himself a pure vitalist or a pure mechanist. In either case, he is performing, as I see it, an overt act of faith; he takes a position which can not be securely grounded in present-day scientific knowledge. He has wandered out into the field of philosophy or of religion, as he has a perfect right to do, and possibly a duty. I merely say that, for my own personal wanderings into such fields, both vitalism and mechanism are superfluous paraphernalia. Apparently the great majority of biologists have not aligned themselves with either party, and this, I take it, is not because they are habitual mugwumps, but rather because neither party has yet given a fully intelligible and acceptable platform. To me it is quite conceivable that this may in time prove to be no issue at all, but it is possible also that it may prove an eternally insoluble one. Meantime, the pure vitalist and pure mechanist undoubtedly serve a useful purpose to the most agnostic of us, in that they each keep the other from deluding us into the belief that he has the whole truth. While it may be fairer to say that some find their own conception of mechanism a helpful pro-

visional hypothesis, and so with vitalism, nevertheless, it does not appear altogether improbable that in the year 5001 there will still be debate on this subject, as well as on that of predestination versus free will.

Some Further Principles of Biology

Now I comment briefly on what I conceive to be some fundamental principles of organic life. I think first of the stream of life or the principle of *continuity*. In the line of ancestry of any living organism there seems to be no break, no discoverable beginning. Organic beings and organic substances die and are lost to the stream, but the stream flows on. It is a one-way stream—like the flow of time. There are no reversals or only temporary and insignificant ones compared with the steady forward flow. In the class of reversals we might classify phenomenon of de-differentiation, second childhood, etc., short-lived reversals preceding the end of life, or other short-lived and adaptive de-differentiations which seem comparable to a backing up for a fresh start.

The second principle, which is closely allied to the first, relates to the condition of *incessant internal organic pressure.* If we pour water into the open space of a weathered and creviced rock, the liquid flows out into every nook and cranny under the influence of pressure largely from without—gravitation, including its manifestation as atmospheric pressure. If we could sterilize the entire crust of the earth, leaving only a small seed plot of living organisms, all experience leads us to believe that, given a sufficient amount of time, the organisms would multiply and severally fill every occupiable niche. In this case, the pressure seems to be largely from within. It is this expansive force of life to which we allude when we speak of "internal pressure," the tendency to take in and assimilate everything assimilable—to grow, to multiply, to crowd everything else out.

The exalted Psalmist, considering the relation of man to his environment, and addressing the Almighty, exclaimed, "Thou makest him to have dominion over the works of Thy fingers, Thou hast put all things under his feet"—a sublime conception, but a poetic exaggeration. Not yet has man gotten quite everything under his feet, but if he has not, it is for no lack of mighty and unremitting effort; for, if man does not now have dominion over the tides and the winds, the insects and the pathogenic organisms, it is not because of any want of the spirit of imperialism. So it is with insects and mollusks. A wise old friend of mine once remarked that the great object in life of an oyster was to convert the whole world into oyster; and if one considers the avidity of an oyster for food and its reproductive capacity, the statement seems not wide of the truth. The biotic potential of the oyster is limited more by outside forces than by its own lack of biotic ambition.

Combining the first two principles into one, we might compare the stream of life to a great river that is continually in flood, and constantly losing over its banks enormous quantities of water while the stream always flows on with approximately undiminished volume. An infinitely greater volume of water has been lost than remains within the banks, but that which is within the stream has an unbroken history of water from its remote and undiscovered headwaters to the mouth—if there be a mouth.

Thirdly, since all organisms in nature are exposed to others, each lives under a condition, not only of pressure from within, but of *pressure from without.* The two-fold organismal pressure may well be compared to atmospheric pressure. In the biosphere, just as in the

atmosphere, nature abhors a vacuum, and living beings are crowded into every possible nook and cranny penetrable in any way by protoplasmic substance. The sand along the banks of the lake, the dark, cold depths of the sea with pressure of a thousand atmospheres, the masses of coral rock, the hot springs, the subterranean waters—all, so far as they are endurable by protoplasm, have their populations of living beings. Protoplasm seems to strain itself to the utmost tolerable limit to obtain dominion over the earth; and each kind crowds the others and limits their abundance, although each may in the long run promote the general welfare.

The inevitable state is one of *approximate equilibrium,* a fourth fundamental principle that runs through the whole organic world. Of course, the physiologist knows about this condition of equilibrium within the cell and between the cell and the surrounding body, but the condition does not prevail there only. The individual as a whole must be in equilibrium with its environment, or it fails to be living. Organisms never live independently, but always in communities made up of themselves and of other organisms of the like or different kinds, so that community life is a fundamental principle; but this, after all, is merely another phase of the law of equilibrium between individuals and species. Within the community, every organism, every kind of organism, finds its *niche,* by which we mean that it finds its function in the general cycle of life.

A fifth biological principle is that of *individuality.* There is always the tendency to form larger or smaller aggregations of protoplasm, each of which seems to possess a measure of individuality. It might, of course, be questioned whether bacteria have individuality, but I can scarcely conceive of the evolution of bacteria—that is to say of the beginning of new kinds—unless the new kinds have arisen from individual variations, which seems to imply individuality.

A sixth fundamental principle seems to be that of change in kinds or species, or *evolution.* If we compare communities in different parts of the world where there seem to occur approximately the same conditions of unlimited external pressure and where very similar niches are to be filled, we generally find different species of organisms filling the niches; or if, with the paleontologists, we look into past times, there seem to have prevailed comparable niches with still other species to fill them. Contrast, for example, the great groups of herbivores of North and South America, Africa and Asia, or those of the present with those of Triassic times; contrast also the large and small herbivores of land with the minute, almost microscopic, vegetarians of the seas. It would be superfluous now to go into all the arguments that lead to a belief in evolution, in descent with modification. We may as well, I think, regard evolution as just as fundamental a principle of life as the tendency to grow and multiply. Possibly it is another aspect of the condition of internal pressure, with some significant part played by the conditions of external pressure to which allusion has been made.

Put in other words, evolution is another expression of the adaptive capacity of protoplasm—always the interaction between "living" and "non-living" as well as between one living thing and other living things. The individual adapts itself to a changing environment as long as it can; when it can no longer adapt itself, it succumbs—it dies. The species adapts itself to changing environment so long as it can; when the capacity for adaptation fails, the species succumbs—it becomes extinct. The statements just made carry an air of plausibility, but, even if their truth be granted, they do not tell us what we want to know—and that is how the

changes, adaptive or not,[6] occur. That is the question to which the biological, biochemical and biophysical sciences address themselves. We study the physiology of the organism to learn how it fulfils its responsive functions. We study the origin of species to see how they (or the germ cells) have responded to whatever they have encountered. Do the statements cited, then, have any value? Only if the attitude of mind, the point of view they imply is helpful, which may or may not be the case. *Persistence with modification* of the individual through "ontogenetic time" and *descent with modification* of the species in "phylogenetic time" may be different aspects of the same basic principle. *Growth, multiplication* and *diversification,* if not one and inseparable, seem at best inevitably linked with the phenomena of life. Physiology and evolution would then be different phases of the one primary division of biological science. Anatomy (and the anatomical aspects of embryology) would be subsidiary to physiology (including the physiological aspect of embryology); morphology and taxonomy would be subsidiary to the physiology of species (evolution); genetics and ecology would be subsidiary to both but more particularly to the latter. Evolution might, indeed, be described as the physiology of the germ cells—for even the most enthusiastic Lamarckian must admit that evolution operates only through modification of germ cells.

As we now approach what may seem to be an over-delayed end, let it be remarked that the spirit of man demands a goal. It appears to be in our very nature to have a purpose, to be aligned with some sort of dependable plan carrying the promise of the ultimate attainment of higher values. Although it is quite without my present province to discuss this aspect of the philosophy of life, I must make this parting allusion in order both to show that this phase of life has not escaped our general recognition, and to emphasize the fact that I conceive of no contradiction between what has been said and the validity of scientific objectives or of social ideals.

[6] Reference has already been made to a seeming, if not a real, ambiguity in the use of the term "adaptive." Personally, I am not prepared to assume that all structural and functional qualities of organisms are "adaptive" in the sense of being useful, although excessive maladjustment is self-destructive. On the other hand, I can see no escape from the conclusion that all living phenomena, even the most useless, if there are such, are "adaptive," in that they owe their origin to protoplasmic responses to something. The muscles of my ear may be presumed to have developed adaptively (responsively); nevertheless, they seem to have no use; and yet they have not handicapped me to such an extent as to prevent my survival to this date.

CHECK-AREAS AS CONTROLS IN LAND USE

By Professor HERBERT C. HANSON

DIRECTOR OF THE NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

Much has been written and said about the depletion of our natural resources. The soil has been mined, the top-soil has been washed or blown away, soluble salts in the soil have been leached out, native plants and animals have been destroyed, streams have been polluted. Statements regarding the extent of the losses have been based largely upon memory of former conditions not upon accurate records. Losses have been so great that agreement is general that waste must be stopped. It would have been more scientific, however, to have planned so that to-day there would be better evidence such as measurements, photographs, descriptions, and, best of all, preserved areas, of former conditions. Had there been such areas available, as standards or checks, to which land under various uses could be compared, misuses of land as we see on all sides to-day might not have resulted.

The investigator or demonstrator usually begins a new task without giving much thought to the soundness of the procedures to be used. He adopts the methods that are in current use and does not give adequate attention to the selection of methods that will yield results which can be readily and directly interpreted. This neglect may be due to lack of emphasis on planning in the literature. Laboratory manuals and papers on methods describe specific procedures in detail but have given little attention to the general design of investigations. But, as is pointed out by Fisher:[1]

> If the design of an experiment is faulty, any method of interpretation which makes it out to be decisive must be faulty too. It is true that there are a great many experimental procedures which are well designed in that they may lead to decisive conclusions, but on other occasions may fail to do so; in such cases, if decisive conclusions are in fact drawn when they are unjustified, we may say that the fault is wholly in the interpretation, not in the design. But the fault of interpretation, even in these cases, lies in overlooking the characteristic features of the design which lead to the result being sometimes inconclusive or conclusive on some questions, but not on all. To understand correctly the one aspect of the problem is to understand the other.

In land utilization programs and in ecological investigations in general there has been less attention paid to the soundness of the plan or design, if one existed at all, than in laboratory and field plot experimentation. But careful designing is needed as much, if not more, in the former fields because of the intricacies of the problems involved. In both of them the relevant and irrelevant factors are extremely difficult to determine, partly because of inherent complexities in the problems themselves and partly because of economic and social interrelationships. One of the most important parts of a plan in land management is a standard or norm or check to which various uses can be compared. In temperature measurements we automatically use standards as zero for cold, or 100° F. for hot. In linear or areal measurements or in weights there are graduated scales; and in many materials definite standards have been established. But in land use there is no adequate standard. The best standard would be areas in their primeval condition, as man found them before alteration with axe or plow or both. The availability of such check areas, now, would permit us to *measure* the losses of top-soil by erosion, the leaching of mineral salts in

[1] R. A. Fisher, "The Design of Experiments," 252 pp. Oliver and Boyd, Edinburgh, 1935.

the soil, the losses in organic matter, alterations in soil structure, the influence of plants and animals, etc.

A number of ecologists have failed to emphasize sufficiently the need for undisturbed areas. Tansley and Chipp[3] state in regard to methods of studying the effects of human activity on vegetation:

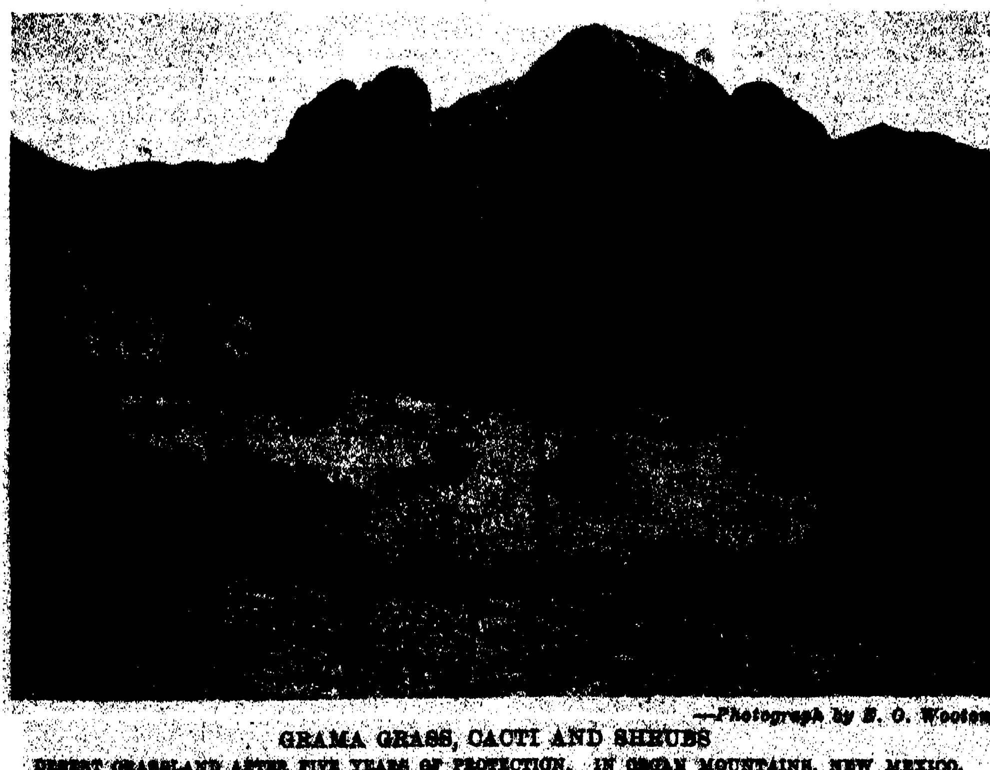
> In this field it is obvious that we can lay down no special technique which should be followed. Experiments are being made everywhere and on every scale by human activity in the exploitation of vegetation. Controls are furnished by areas which have not been interfered with. Careful and continuous comparative observation of differently treated areas, or of different types as they naturally occur, is often all that is necessary for the broad solution of practical problems.

This procedure is definitely inadequate because areas which have not been interfered with are extremely scarce, if present at all, in some regions, as the prairies and plains of the United States. While comparison of differently treated areas yields valuable information it is difficult to fully evaluate it unless data from controls or check areas are available.

F. E. Clements wrote that areas are available in which the original relations of the dominant species obtain, especially in grasslands. By using such areas as standards for comparison, practically all degrees of change may be evaluated objectively and the task of interpretation facilitated. He also stated that trackways and roadways furnish favorable sites for securing evidence as to the course of modification and the manner of control of grassland that can not be matched elsewhere.

In many places, however, rights-of-way are unsuitable because they have a layer of cinders over the surface and the soil conditions are modified, and roadsides are

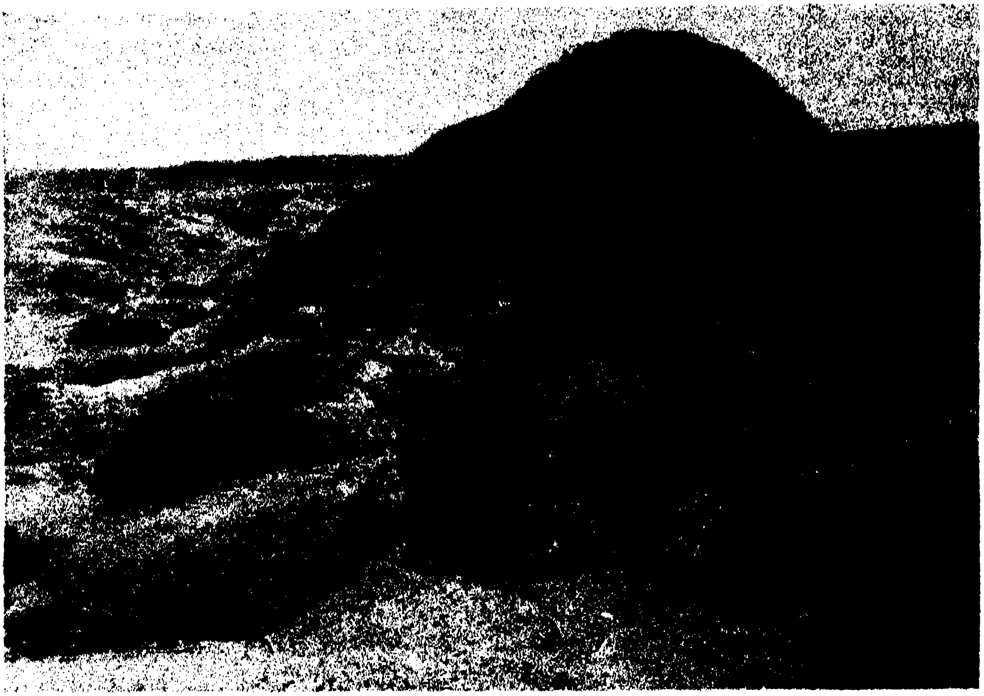
[3] A. G. Tansley and T. F. Chipp, "Aims and Methods in the Study of Vegetation," 383 pp. London, 1926.



—Photograph by E. O. Wooton

GRAMA GRASS, CACTI AND SHRUBS

DESERT GRASSLAND AFTER FIVE YEARS OF PROTECTION. IN ORGAN MOUNTAINS, NEW MEXICO.



HOW MUCH OF THIS EROSION IS DUE TO OVERGRAZING?
NOTE NUMEROUS CATTLE TRAILS ON BANKS. CEDARS GROWING ON NORTH SIDE OF BUTTE. GRASSES ARE CHIEFLY WESTERN WHEATGRASS AND BLUE GRAMA. BADLANDS NEAR MEDORA, NORTH DAKOTA.

usually more or less modified by erosion, grazing, drifting of snow or soil, etc. Professor V. E. Shelford[3] and many others have for years been showing the necessity for adequate controls in the form of undisturbed areas, of sufficient size so that natural processes may operate. Pough[4] wrote:

The greatest handicap under which ecologists and botanists who are trying to solve some of the present problems resulting from land misuse are laboring is the scarcity of areas that man has not disturbed, as only in these can some idea of the original plant and animal association be obtained. It is to the original climax communities of plants and animals that we must go to observe nature in a state of maximum stability, and it is toward the restoration of as close an approximation of these communities as is possible that we must go if we are to insure permanent productivity of the land on which man's continued tenure of it depends. Man's utilization of land involves a shift to different species, and here management is necessary, but a management that utilizes the same fundamental balancing factors that operate automatically in a primitive area.

Let us not be so short-sighted as to fail to profit from past mistakes, in not preserving a study area in undisturbed state in each great biotic region of the country. It is not yet too late to save a few, and far from being a luxury, it may be one of the wisest investments that the country has ever made—natural yardsticks to measure man's land management by. (p. 1078.)

Walter Taylor[5] has been properly emphasizing the need for natural areas as standards to serve in land utilization:

Mr. R. D. Forbes, Director of the Allegheny Forest Experiment Station, writing in *American Forests*, February, 1934, says that "999 acres of forest land out of a thousand in the territory of the Allegheny Forest Experiment Station have been cut over. The thousandth is virgin timber. The thousandth acre will repay careful

[3] V. E. Shelford, "The Importance of Natural Areas to Biology and Agriculture." In "The Naturalists' Guide to the Americas," pp. 13–14, 1926.

[4] *Jour. Forestry*, 3: 1077–1078, 1936.

[5] W. P. Taylor, *Ecology*, 15: 328–329, 1934.

study." He goes on to point out that on the 999 acres nature's record has been often hopelessly obscured by the heavy hand of man and by fire. In the Southwest where so great a proportion of the land is given over to grazing by live stock, biologists find that it is very difficult to find any land at all under natural conditions. In some localities, over-grazed over a vast extent of country, there is no thousandth acre. This means that there *is no norm* with which to compare the vegetation, animal life, and the soil, as they now appear. One may interview old-timers and get from them valuable hints as to the early condition of the country, its soils, streams, grasses, brush, trees, and wild life—but conclusive demonstration is lacking. The existing situation emphasizes in no uncertain terms the need for saving sample tracts in all important types under as nearly as possible original conditions to serve as a guide for present practice. Disturbance of original conditions is inevitable, under the best administrative regulation, but if areas showing natural conditions were available for observation, the administrator and his scientific advisers would be able to determine just how far management could safely go in modifying the original conditions in the process of grazing or other land use.

The writer can add to Taylor's testimony that in the northern Great Plains the thousandth acre has all but disappeared. During the past few years the author has been studying the characteristics of grassland types, especially in relation to soil characters. One of the chief difficulties has been to find samples of grassland that still possess characteristics not dominated by influence of overgrazing, plowing or other man-made disturbance. The area immediately surrounding the buildings in Wind Cave National Park in South Dakota is one of the extremely rare places where good grassland can be studied. It appears to have been grazed only occasionally by a few horses for many years.

It is too haphazard to place trust in finding field-corners, railroad rights-of-way, cemeteries, etc., which can be used as controls by which to measure land use. Definite provision must be made

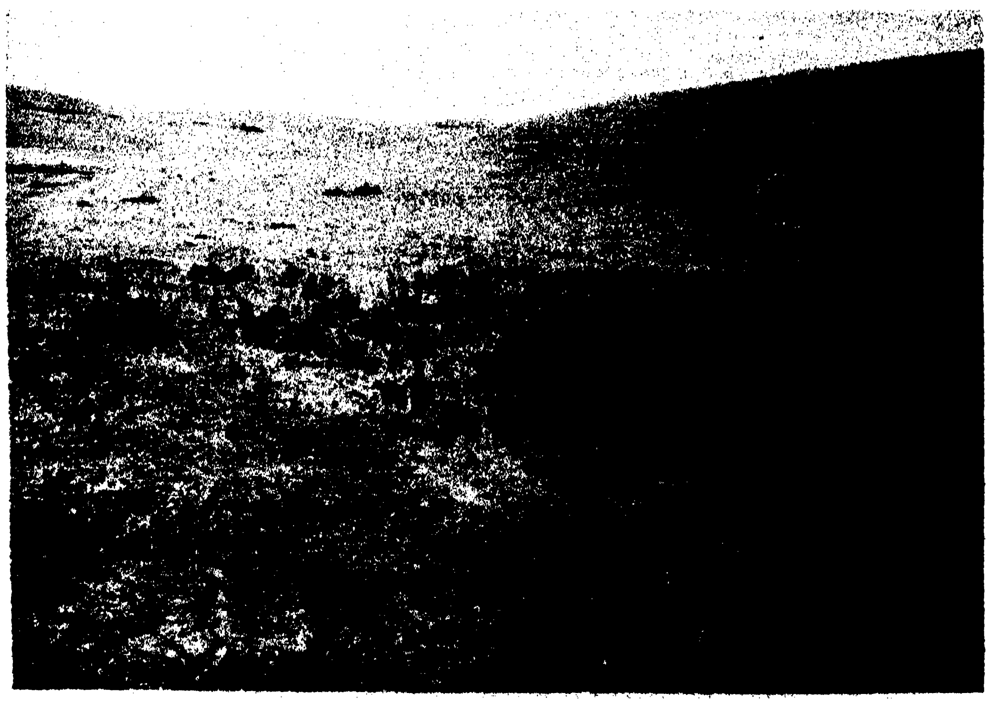
VEGETATION AND SOIL

BEING DESTROYED BY OVERGRAZING BY SHEEP AROUND A WATERHOLE. LITTLE IS LEFT OF THE ORIGINAL VEGETATION ON THIS RANGE. BADLANDS NEAR MEDORA, NORTH DAKOTA.

for setting aside areas of large enough size in the major biotic communities so that the intimately interrelated functions of plants and animals may have full scope to operate under the influence of all environmental conditions. The National Park Service and the Forest Service have made a start. Undisturbed areas under their control can be used as check areas by which to measure land use in the surrounding territory, where climatic, soil and topographic conditions are similar. Such areas, however, are inadequate both in number, size and distribution. Many additional land-use controls are needed. Every experiment station, including the state agricultural experiment stations and their substations, should provide for a sufficient number. Every program of land utilization must include such areas in order that the effectiveness of the program may be adequately measured.

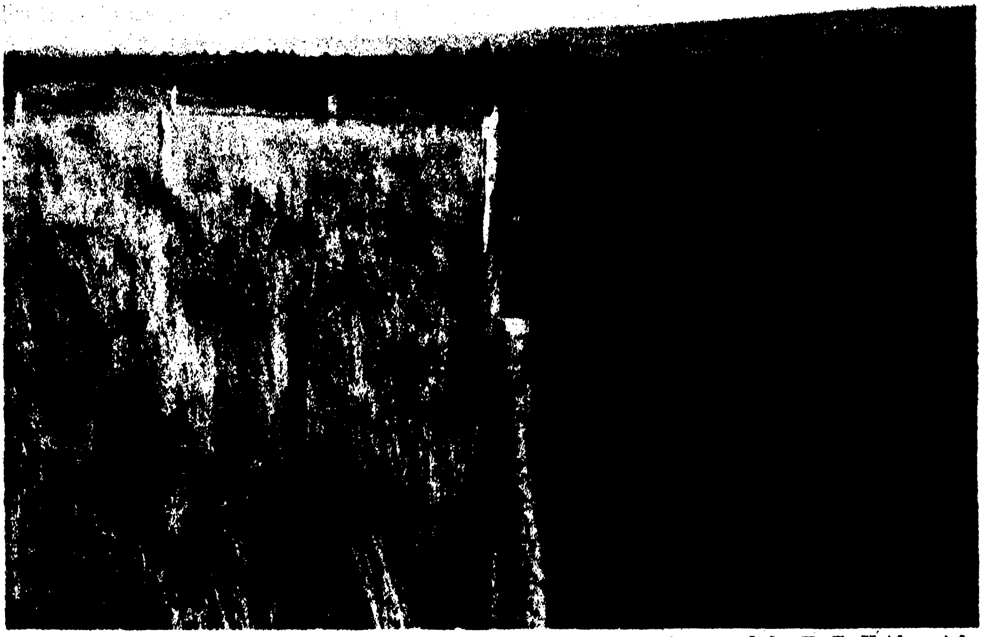
Professor S. A. Graham in a recent statement summarized values of such areas and suggestions regarding their administration as follows:

In brief, it appears desirable that natural areas of sufficient size to include the cruising radius of the most motile non-migratory animals be set up in the various geological areas; that these areas should include some of the few remaining virgin lands, as well as devastated lands, the natural recovery of which should be recorded; that provision should be made for the protection of these areas from the influence of man, and in most instances, from fire; that provision be made for keeping, as a routine, continuous records of meteorological and ecological conditions by the research organization most closely associated administratively with each area; that research by cooperating organizations and individuals be encouraged, but that each project be scrutinized by a competent board to



DROUGHT COMBINED WITH GRASSHOPPERS

DESTROYED ALL FORAGE GROWTH IN WIDE AREAS OF SOUTHWESTERN NORTH DAKOTA IN 1936. NOTE PILES OF GRASS STEMS, CUT OFF BY GRASSHOPPERS, AND WASHED INTO THIS VALLEY BY A TORRENTIAL RAIN, VERY LITTLE OF WHICH PENETRATED THE DRY SOIL. CHECK-AREAS ARE NEEDED TO FURNISH INFORMATION TO SHOW HOW TO WITHSTAND SUCH CLIMATIC AND BIOTIC FORCES. NEAR MEDORA, NORTH DAKOTA.



—*Photograph by V. T. Heidenreich*

THE AREA ON THE LEFT HAS BEEN PROTECTED FROM WILD HORSES FOR TWO SEASONS. NEAR TOPPENISH, WASHINGTON.

determine its probable effects so that any that endanger natural conditions may be rejected. That any administrative developments such as necessary roads or trails be located and constructed in such a manner as to cause a minimum of disturbance; that public access to the areas should be limited to foot trails from camps located on or near the boundary. Such recreational facilities should not, however, be regarded as the primary function, but rather as a means of protection from the results of the undue pressure to open the areas to the public that would almost certainly be brought to bear if the public were entirely excluded. The scientific results that might be expected to come from the establishment and study of these lands would be both academic and practical. In due course of time the laws governing the interaction of living things would become apparent, and the application of the fundamental principles thus disclosed would lead to wiser and more effective use of our natural resources than at present.

It appears desirable, and perhaps necessary, at this time to describe the need for check-areas in some specific land-use problems. The selection of problems was limited largely to those presented in recent literature; others, of probably greater importance, might have been selected.

Control of Insect Pests

In understanding conditions which most favor pests a knowledge of their original habitat is often very important and will save years of work on the part of investigators. For example the chinch bug was originally found on grasses in waste places along the coast of the Carolinas. Rainy, hot seasons similar to those found in the original area are favorable to the chinch bug. Knowledge of the climate and other conditions in the original habitat would have saved much useless speculation and misinterpretation.[6]

Much remains to be learned about grasshoppers, especially in regard to the relationship of breeding habits and building up of numbers into plague proportions to types of grasslands and grazing conditions. Treherne and Buckell re-

[6] V. E. Shelford, *loc. cit.*, p. 14.

ported that in British Columbia the most injurious species of grasshoppers, as *Camnula pellucide*, prefer to lay their eggs in overgrazed, open, parched, low-grassed areas rather than in ungrazed or lightly grazed areas of tall bunchgrass (*Agropyron tenerum*). In North Dakota Professor J. A. Munro found "that fields of succulent crops for food and adjacent sod land for egg laying offer more favorable conditions for grasshoppers than existed before the native sod was disturbed by agriculture." Check-areas of native grassland are needed to secure information that is essential for the control of grasshopper infestations, which in some years destroy 50 per cent. and more of the vegetation in parts of the Northern Great Plains. Ungrazed areas would serve as adequate standards to which lightly grazed, heavily grazed, plowed and other areas could be compared, and the effects of grasshoppers more definitely measured.

There are numerous insect pests on crop plants, as the Hessian fly, wireworms, false wireworm and army cutworm, some of which were present in our grasslands before cultivation. The natural checks on their increase were parasites, rodents, birds, etc. Undisturbed pieces of grassland to-day would serve as reservoirs of knowledge regarding natural checks, breeding areas for these control organisms and sources from which parasites might be secured for increase. The destruction of all natural grassland areas is possibly leading to the destruction of many unknown natural control organisms. Since insect infestations appear to be increasing in severity and number man will be compelled, if he is to remain supreme, to use all possible resources in controlling them. No longer can he neglect to furnish the opportunities, provided by undisturbed natural areas, to learn facts that are essential to man's progress and mastery.

Control of Rodents and Carnivores

There appears to be little doubt but that some campaigns for the eradication of some rodents and carnivores have been based upon inadequate knowledge of the role of the animal attacked. There is no question, of course, about the need for destroying the Norwegian rat, plague-carrying rodents and others whose destructiveness is proven beyond doubt. But when there is doubt that the harm wrought by an animal may be balanced, or even more than balanced, by the good it does, then attempted eradication of the animal should be delayed until accurate information is secured. Once the animal is decimated in numbers there may be great difficulty in bringing it back. One of the best ways to evaluate the effects of various kinds of animals is by means of natural areas, which must be of sufficient size so the animals can act naturally. Although bounties are given in some states for the destruction of the coyote, O. J. Murie,[7] of the Biological Survey, concluded on the basis of a 4-year study of 714 fecal samples that "the fur value of the coyote, the potential value of its beneficial habits, the fact that the animal is intrinsically interesting and has a scientific value, and what may be termed an inspirational value, however much derided, can be given considerable weight. After all, the wildlife question must resolve itself into sharing the values of the various species among the complex group of participants in the out-of-door and wilderness wealth, with fairness to all groups. Under such considerations with possible local exceptions, the coyote deserves to remain a part of the Jackson Hole fauna, with only a minimum of control, and that only in the case of unusual local situations."

Taylor, Vorhies and Lister found that jack rabbits in Arizona were more numer-

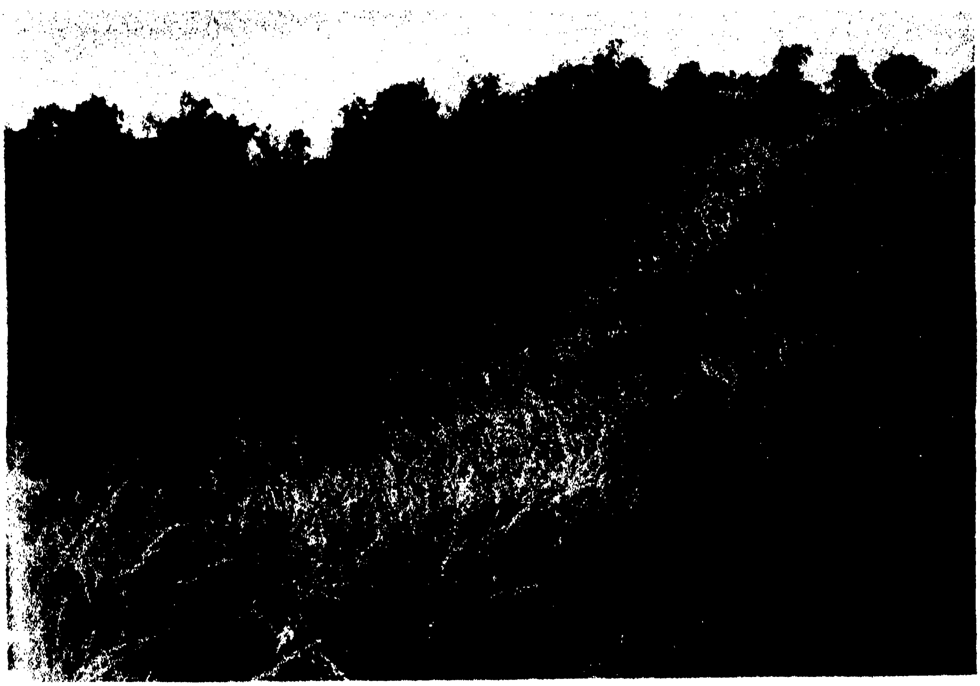
[7] U. S. Dept. Agric. Cir. 362, pp. 23–24, 1935.

IS THE CLIMAX VEGETATION HERE SAGEBRUSH OR GRASS?

THE SAGEBRUSH ON THE AREA IN THE FOREGROUND WAS BURNED AND THEN PROTECTED FROM CATTLE, AND THE AREA IN THE LEFT FOREGROUND WAS PROTECTED IN ADDITION FROM RODENTS. LARAMIE RIVER VALLEY, COLORADO.

THE RESULTS OF OVERGRAZING

OVERGRAZING STARTED THE DEVASTATION BY WIND ON THIS SANDY LAND NEAR MCLEOD, NORTH DAKOTA. AREAS OF UNDISTURBED VEGETATION ARE ESPECIALLY NEEDED AS MEASURING STICKS FOR LAND USE IN PROBLEM AREAS AS THIS ONE. COMPARE WITH THE NEXT PICTURE.



ARE THE TREES CLIMAX HERE?
BUR OAKS AND SANDGRASS IN A PARTIALLY PROTECTED AREA IN SAND HILLS NEAR MCLEOD, NORTH DAKOTA.

ous on overgrazed grassland than on undergrazed or lightly grazed areas. The effects of overgrazing are seen not only in the increase in weeds and annual grasses but also in animal "weeds." In Oklahoma, Phillips showed that jack rabbits, ground squirrels, pocket gophers and deermice were more numerous on moderately overgrazed grasslands than on undisturbed ones, but cottontails and cotton rats were more numerous on the latter. A rodent may be more injurious than beneficial in some areas but wholly beneficial in others. According to W. L. Burnett in eastern Colorado the striped ground squirrel is injurious, but in the foothills it is valuable because it destroys injurious insects. In regard to the Wyoming ground squirrel Burnett emphasized the need for securing as complete knowledge as possible of its "intricate relationship" to the environment, its food habits, effects on native and cultivated plants and the effects of wet and dry seasons upon fecundity. In order to secure comprehensive knowledge on these subjects check-areas left in natural condition are essential. Vorhies and Taylor[8] in the following quotation have stated the importance of these check-areas to land use so clearly that it is difficult to understand how the provision for adequate control areas can be neglected by any one connected with the formulation of land-use plans.

> We feel that in any bio-ecological problem, involving the plants, animals, soil, and climate of particular areas, it is desirable and often essential to have control areas of large size, *i.e.*, several hundred or preferably several thousand acres, under natural conditions, to compare with areas subject to various degrees of modification by man. . . . In the absence of such areas the answers will lack something in definiteness and conclusiveness. Among the problems to the solu-

[8] C. T. Vorhies and W. P. Taylor, *Ariz. Agric. Exp. Sta. Tech. Bul.*, No. 49, 1933.

tion of which large-sized control areas might be expected to contribute are: life histories, soil relations, and food habits of native animals (rodents, birds, insects, etc.); most productive management of range; range rehabilitation; carrying capacity of the range for livestock, game and native rodents; game problems; and erosion on range lands [p. 475].

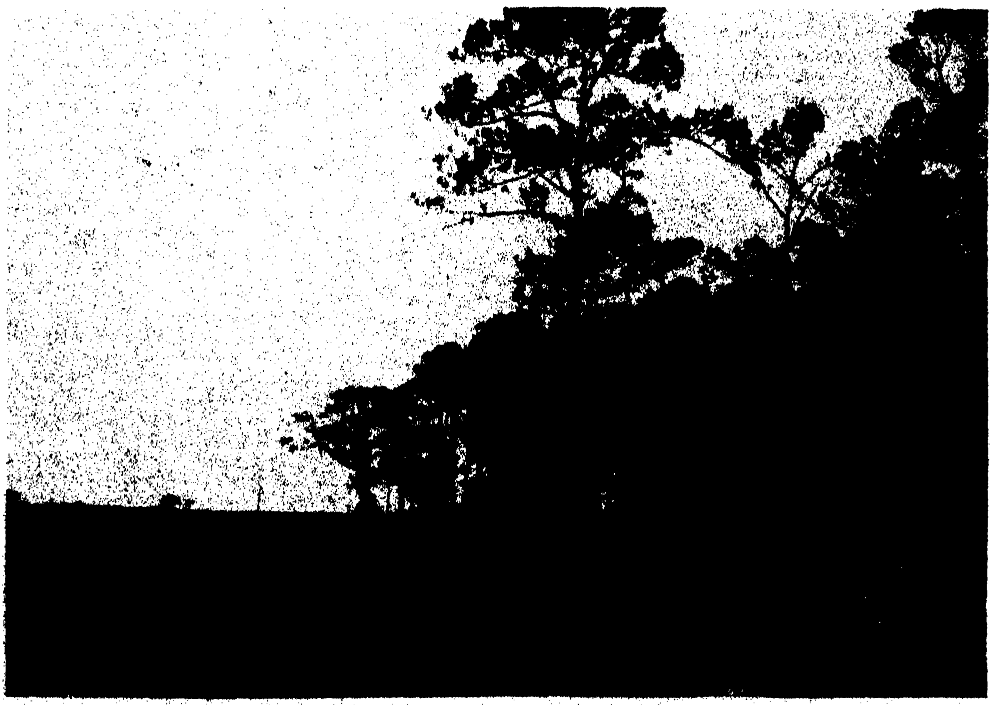
It is man's job to understand the balance (of nature) well enough to be sure when he changes it, that the new arrangement will be to his advantage. The fact that man as yet understands very little of the natural world is an excellent argument that he should be cautious in upsetting nature's arrangements [pp. 575–576].

The best control program (for predators, rodents, etc.) is that which interferes least with the orderly relationship of natural species, but which at the same time helps to assure success to the agriculture, range management and forestry on which man depends for his own existence [p. 576].

Soil Management

Wise use of the soil is dependent upon as complete information as can be secured regarding many complex subjects, such as; composition of the soil, its development, biological and physical processes occurring at various depths, interrelationships of different kinds of soil with all sorts of plants and animals from microscopic forms to trees and mammals, climatic influences and others. Control of run-off and erosion, rotation of crops, irrigation, drainage, maximum use of soil moisture, improvement and maintenance of soil fertility are dependent upon comprehensive knowledge of these subjects. Soil depletion has been serious in the United States partly because land users and planners have neglected known facts and partly because the foundation of knowledge has not been adequate to support the great superstructure of scientific land utilization.

Land planning for improvement and use is handicapped in many places by the lack of scientific knowledge of virgin con-



—*Photograph by L. D. Love*

SOUTHERN LIMIT OF LOBLOLLY PINE IN THE VICINITY OF NEW ORLEANS

THE INTRICATE INTERRELATIONSHIPS OF PRAIRIE, FOREST AND ANNUAL FIRES REQUIRE DATA FROM PROTECTED NATURAL AREAS FOR THEIR SOLUTION.

RED AND JACK PINES, PAPER BIRCH AND UNDERGROWTH OF HAZEL
IN ITASCA STATE PARK, MINNESOTA. FULLY PROTECTED AREAS ARE NECESSARY TO DETERMINE THE COURSE AND RATE OF NATURAL PROCESSES AS COMPETITION BETWEEN SPECIES, SOIL CHANGES, AND INTERRELATIONSHIPS OF PLANTS AND ANIMALS.

PINE RIDGE COUNTRY NEAR CHADRON, NEBRASKA
WHERE THE WESTERN YELLOW PINES AND EASTERN DECIDUOUS FOREST MEET IN THE PLAINS GRASSLAND. THE RESOURCES THAT EACH OF THESE CLIMAXES CAN PROVIDE ARE KNOWN ONLY IN SMALL PART.

ditions. In many places no areas are left in which the original grass or forest remains. The axe and plow, too often followed by disastrous water or wind erosion, have so changed original soil conditions that dependence is placed for knowledge concerning them on descriptions in historical accounts of explorers and in novels, such as the following from "Vandemark's Folly" by Quick.

> The plow itself was long, low, and yacht-like in form; a curved blade of polished steel. The plowman walked behind it in a clean new path, sheared as smooth as a concrete pavement, with not a lump of crumbled earth under his feet—a cool, moist, black path of richness. The furrow slice was a long, almost unbroken ribbon of turf, each one laid smoothly against the former strand, and under it lay crumpled and crushed the layer of grass and flowers. The plow point was long and tapering, like the prow of a clipper, and ran far out under the beam, and above it was the rolling colter, a circular blade of steel, which cut the edge of the furrow as cleanly as cheese. The lay of the plow, filed sharp at every round, lay flat, and clove the slice neatly from the bosom of earth where it had lain from the beginning of time. As the team steadily pulled the machine along, I heard a curious thrilling sound as the knife went through the roots, a sort of murmuring as of protest at this violation—and once in a while, the whole engine, and the arms of the plowman also, felt a jar, like that of a ship striking a hidden rock, as the share cut through a red-root—a stout root of wood, like red cedar or mahogany, sometimes as large as one's arm, topped with a clump of tough twigs with clusters of pretty white blossoms [p. 28].

How much better it would be to have samples of land preserved as much as possible, in their original conditions of soil, vegetation and animal life! In some places the setting aside of such primeval check-areas may still be possible. In other places the next best thing should be done, namely, establishment in each important land region of the best check-areas that are available to use as controls in accumulating sufficient information for scientific land use.

LAND USE IN FARMING REGIONS
IS USUALLY NOT FULLY SCIENTIFIC BECAUSE STANDARDS OF COMPARISON IN THE FORM OF NATURAL AREAS HAVE NOT BEEN SET ASIDE. NEAR MINERAL POINT, WISCONSIN.

Taylor[9] points out that soil fertility may be influenced more by soil animals than is realized, in such activities as accumulation of animal bodies or parts and

[9] W. P. Taylor, *Ecology*, 16: 127–136, 1935.

A FOREST IN ROCKY MOUNTAIN NATIONAL PARK

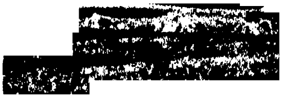
LOOKING DOWN UPON SPRUCES AND FIRS FROM ABOVE TIMBER LINE IN ROCKY MOUNTAIN NATIONAL PARK, COLORADO. ACTIVE SUPPORT IS NEEDED FOR THE NATIONAL PARK SERVICE TO CONTINUE PROTECTING AREAS SUCH AS THIS IN THEIR NATURAL CONDITION.

food and nesting materials, burrow digging, intermixing soil, dam building and flooding, etc. In a footnote on page 128 he quotes J. F. Breazeale, soils-specialist of the U. S. Bureau of Plant Industry and the University of Arizona, as follows:

> Personally I have never seen a poor or unproductive soil which contained an abundant fauna. I am daily getting more and more of the opinion that results which we get with fertilizers are indirect, that is, we fertilize the soil flora and probably the fauna, and not necessarily the crop. There is a weak link in every chain and in many an unproductive soil the absence of fauna may be the weak link. Animals certainly bring life and vitamin-like substances into the soil.

In recent years soil has started blowing from fields that have not been subjected to serious wind erosion during the previous 20 to 40 years of cultivation. It has been thought that continuous cultivation, accompanied in the last few years by drought, has destroyed the humus, or other binding properties, added to the soil by roots and soil organisms over centuries of time. The crumb structure broke down to single grains, giving the wind a chance to carry the soil away, grinding down soil in adjacent fields to similar structure as the dust clouds swept across the country-side. Check-areas, in their original condition, would aid in determining causes and control for the great increase in soil blowing in the prairies and plains. In too many places the best that can be done, now, is to provide such check-areas for securing information as a basis for scientific land-use in the future.

Soil develops under the influence of the character of the parent material, the climate and the plants and animals living in and on it. Comprehensive knowledge of a soil requires thorough appraisal of the influence of each of these factors. If the native fauna and flora are de-



EVEN AT EXPERIMENT STATIONS
THE USE OF NATURAL AREAS AS CONTROLS HAS BEEN NEGLECTED. EDGELEY, NORTH DAKOTA.

stroyed, as by plowing, does the soil gradually become depleted? This question is difficult to answer unless check-areas in the form of original conditions can be used for comparison. In a recent study Hanson and Whitman attempted to describe some of the relationships between type of grassland cover to characteristics of the soil, a subject of fundamental importance in soil and range survey work, in range management, in soil development and in plant succession. One of the chief difficulties encountered in this study was to find areas of grassland where direct plant-soil relationships, unmodified by injury from grazing, plowing or other agency, were still present. Such areas were extremely scarce in the Northern Great Plains. Usually the relationship of the vegetation was not directly with the soil but with disturbing agencies. Undisturbed check-areas are essential for such studies. Tansley in a recent paper raised some fundamental questions regarding vegetation-soil relationships, which can only be answered by data from studies on undisturbed natural areas. Scientific land use requires answers to such questions as Tansley raises:

It is a simple and attractive idea that development of the soil profile runs *pari passu* with development of the vegetation it bears, and that consequently the mature climatic soil type corresponds and co-exists with the climatic climax community. *It is, however, quite premature and probably untrue to make any such general assertion.* It may very well be that in particular cases such a correspondence actually exists. But on the other hand, even when profile development under the influence of climate is perfectly normal and regular, the climatic climax community may establish itself long before the soil is mature, and may not be substantially altered by the later stages of profile maturation. Again a climatic climax may establish itself on a soil which is *kept immature* by geological and physiographic causes, as on a steep slope. And finally it is now generally agreed by pedologists that some rocks, owing to the simplicity of their composition, produce

soils which can *never* form the normal climatic mature profile, and these may or may not bear the typical climatic climax vegetation.

Weaver and Flory[10] have demonstrated the value of native grassland in determining the effects of cropping to corn for three years near Lincoln, Nebraska. They found that the soil in the cornfield became heavier per unit of volume, decreased 12 per cent. in porosity, and its rate of percolation was retarded 42 per cent. or more, causing greater run-off and erosion. Mean temperatures averaged 3.9° F. lower at night and 2.7° lower in the daytime in the prairie than in the field. In some very hot weeks the maximum temperature was up to 11° F. higher in the field. The soil temperatures were lower, relative humidities higher, and evaporation losses lower in the prairie; so the grassland exerted considerable stabilizing influence in tempering extremes.

The applications of lessons learned from a careful study of vegetation are manifold. In this period of the reclaiming of marginal lands, of planning great projects to ameliorate erosion, of developing scientific plans for land utilization, and of definite planning to establish cropping systems best calculated to produce economic returns from the different types of soil, we may profitably consider the natural environment. Not until the native environment in its relations to water, humidity, temperature fluctuations, and other critical factors of both air and soil has been compared with that of overgrazed and cropped areas will it be known how widely we are departing from Nature's plan of a stable environment.

Again the conclusion is inescapable that undisturbed natural areas are needed as controls in scientific land use.

Forest and Range Management

Foresters have recognized, perhaps more than any other group, the need for control areas. An important step was made in 1930 when the following National Forest regulations went into effect:

The forester shall determine, define and permanently record a series of areas of national forest land to be known as experimental forests, sufficient in number and extent adequately to provide for the experimental work necessary as a basis for forest production or forest and range production in each forest region, these areas to be dedicated to and used for research; also where necessary a supplemental series of areas for range investigations to be known as experimental ranges; and a series to be known as natural areas sufficient in number and extent adequately to illustrate or typify virgin conditions of forest or range growth in each forest or range region, to be retained in a virgin or unmodified condition for purposes of science, research and education; and a series of areas to be known as primitive areas within which will be maintained primitive conditions of environment, transportaton, habitation and subsistence, with a view to conserving the value of such areas for purposes of public education and recreation. Within any areas so designated, except for permanent improvements needed in experimental forests and ranges, no occupancy under special use permit shall be allowed, or the construction of permanent improvements by any public agency be permitted, except as authorized by the forester or the secretary.[11]

In January, 1937, according to L. S. Bean, acting chief of the Division of Recreation and Lands of the U. S. Forest Service, there were 67 *primitive areas*, varying in size from 5,000 to 1,087,744 acres; 26 of which are *roadless areas* and 41 wild areas in the National Forests. The chief difference between these areas is in size; the minimum size of the former is 100,000 acres for forest and 500,000 acres for desert. *Natural areas*, called *botanical areas* in the new classification, include 37,066 acres in 29 areas. They differ from primitive areas chiefly in being smaller or in showing past disturbances of the vegetation. There were on this date 50 *experimental forest and range areas* comprising 583,849 acres. A number of foresters have described the needs for these check areas. Dr. C. F. Korstian wrote in 1926 that "so far as the forester is concerned, the main reason for preserving natural areas is to retain a standard of accomplishment of nature

[10] J. E. Weaver and E. L. Flory, *Ecology*, 15: 333–347, 1934.

[11] L. F. Kneipp, *Science*, 72: 560–561, 1930.

alone, to serve as a guide by which the correctness of the forester's efforts to improve on nature may be gauged." Ashe in 1926 presented the uses of check-areas in greater detail:

The study of the unmodified areas, in connection with those which are modified, will indicate the extent to which it will be possible to deviate from the normal and yet retain the equilibrium necessary for maintaining the factors of the locality. Such studies will determine whether it will be possible economically to replace one species by another, whether it will be advantageous to substitute a pure coniferous stand for one of mixed hardwoods, or if not, as to what proportion of the stand the conifers can occupy. The natural areas must in large measure serve as the means of developing our silviculture; their elimination from exploitation and their preservation is essential to that end.

Management of Marshes, Lakes and Other Bodies of Water

As indicated by Adams, public planning of water resources should be based primarily upon social values, rather than solely upon economic values; public interest should be dominating; and scientific data are essential to serve as a foundation. Some of the primary uses of marsh and water areas are: supplies for drinking water, transportation, recreation, habitat for wild animals and flood and drainage control. Leopold has raised a number of questions regarding the management of marshes adjacent to the Wisconsin River in the vicinity of Wisconsin Rapids, Wis. Some of these questions are: How shall dam-building to raise water levels be divided between engineers and beavers? What is the relationship between cattails, ducks and muskrats? Do mowed or unmowed hay meadows favor prairie chickens? What are relationships between deer and tamarack, birch and grouse? These questions can

INSTEAD OF THE MORE USUAL V-SHAPED ERODING DRAW

LAND-USE PLANNING HERE HAS PERMITTED THE BEAVERS TO MAKE A WIDE, WATER-FILLED VALLEY. IN WESTERN NORTH DAKOTA NEAR KILDEER.

not be readily answered, especially since economic forces and public sentiment have played and will probably continue to play important roles. The answers to these questions would be more scientific, and probably more readily accepted by economic forces, if they could be based upon data secured from study of marshes which had been left in their natural condition. Since such areas are not available now, it appears that it would be sensible to set aside well-selected areas of sufficient size to use as check-areas for future planning and to measure present uses. It would be economical in the end to have such areas because it would save much experimentation by the trial-and-error method and it would give land planners more facts to use in designing their work and interpreting results.

Pollution of streams and lakes, drainage, irrigation, erection of dams, construction of recreational facilities, etc., have modified conditions in so many bodies of water and marshes that original conditions have been almost entirely destroyed. Numerous plants and animals and the environments in which they live have thus been lost to men and women, and saddest of all, to children, at a time when there is more leisure for their enjoyment. In fact, these resources, which have been lost in large measure, may be considered vital in planning for future land use, if the chief basis is social values. Everything should be done to restore as much as possible these wasted aquatic resources. Natural areas of large enough size are needed first of all as demonstrations of the resources that nature can provide for a well-rounded program of land use.

Conclusion

Scientific land use requires as careful planning as is humanly possible. The plans should be thoroughly studied from all angles. All sources should be tapped for relevant data. Much land planning is unavoidably experimental. The recent emphasis on design and interpretation in biological experiments applies with even greater weight to work in land use. An important source of basic information, that has been neglected in the past, is land in natural condition used as checks, controls or standards by which land may be measured. Planning, if it is to be as serviceable to humanity as possible, must provide these check-areas, even though land in original condition is no longer available. Carefully selected tracts must be set aside as soon as possible in each of the natural land-use areas of the United States by the various state and federal agencies concerned with land-use problems. The Forest Service and National Park Service have taken the lead; other federal and state agencies must follow if land utilization is to be based as fully as possible upon science.

FOSSIL FISH LOCALITIES IN THE GREEN RIVER EOCENE OF WYOMING

By CURTIS J. HESSE
ASSISTANT CURATOR OF THE MUSEUM OF PALEONTOLOGY, AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS

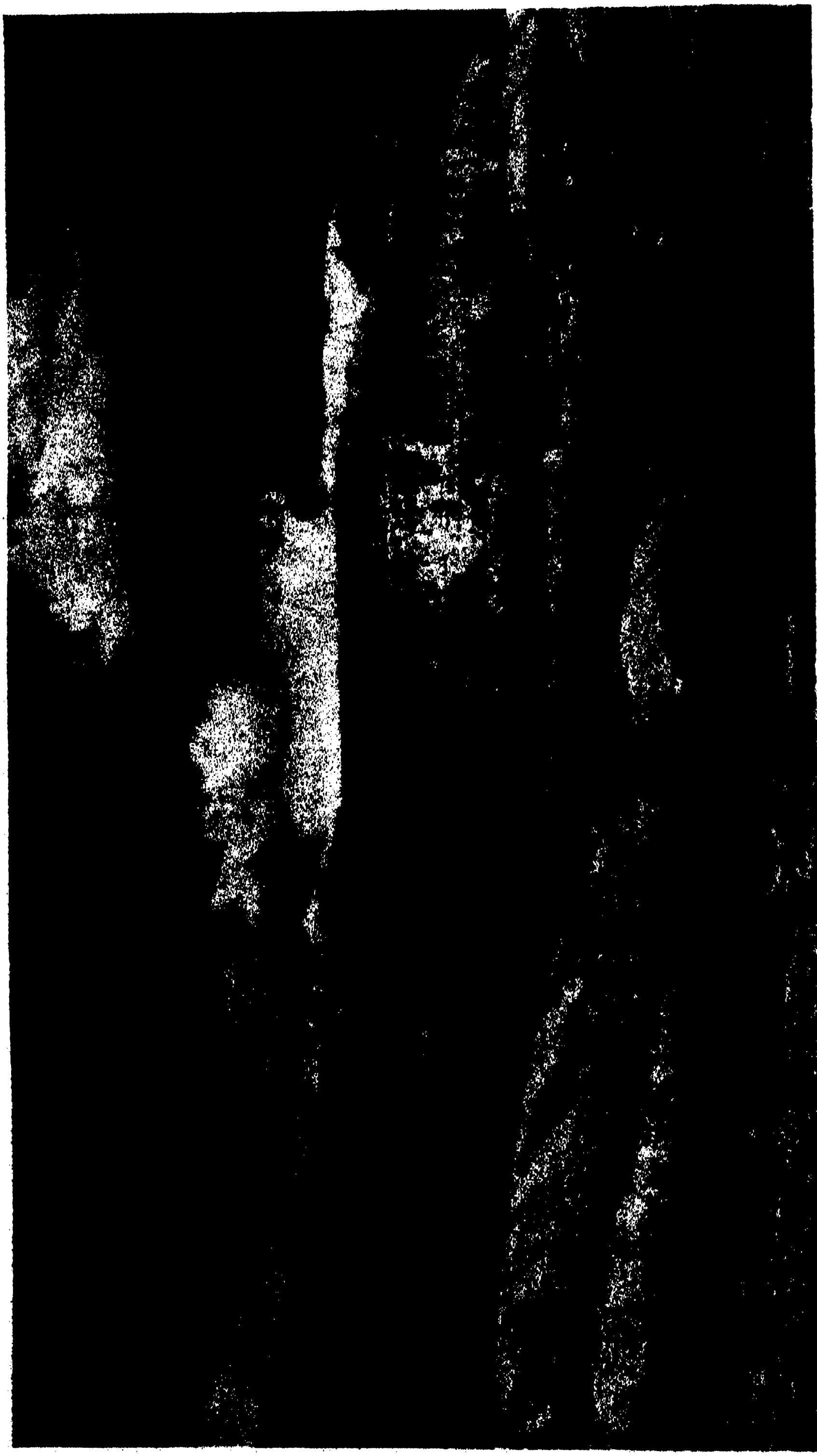
Few museums in the world, certainly none of the larger ones, are without specimens of the fossil fishes from the Green River shales of southwest Wyoming. These are prize exhibition specimens and no other fossil-bearing formation in North America has produced so many and such characteristic fossils as this great series of lake beds.

So far as can be determined, the first scientific notice of these remarkable fishes was published by Dr. Joseph Leidy in 1856. He described the fossil herring, *Clupea humilis* (now known as *Knightia alta*), from a specimen sent to him by Dr. John Evans. The specimen had been picked up "on the Green River." From that year on, although probably known to local people, the locality received no more attention from scientists. In 1868, when the Union Pacific Railroad was being built through western Wyoming, Green River Station became a place of importance. At the western edge of the town, a long cut was made in the shale bluffs along the river. So many fossil fishes were found that this part of the right-of-way was named "Petrified Fish Cut," and the abundant material brought to the attention of the Hayden Geological Survey.

From the collections made by the Hayden Survey and from donations of local people the first adequate idea of the fauna, as well as of its abundance, was obtained. This collection was described by E. D. Cope in 1870 as a part of the Hayden Survey report of that year. Following this in close order came a series of papers by Cope on this fauna, some duplicating previous papers, others brief notes and appendices in unrelated papers. In this confusing mass of literature over twenty-five species of fishes were described, but no figures were given. From 1877 until the publication of Cope's "Bible" in 1884 nothing more appeared in print. In the "Bible" the entire series was reviewed and most of the species were figured. The list now included thirty species, and possibly more, for many of the locality references were obscure or left out entirely. Since that time few scientific papers have been written on these fishes; but now and then an additional species has been added to the list.

These fossil fishes are so beautifully preserved and so common that one would expect some detailed account of the localities from which they were collected; yet none seems to have been published. Cope, in 1877, speaks of three localities; the "Petrified Fish Cut" west of Green River, a locality "near the mouth of Labarge Creek" which he discovered in 1872, and a third "near the main line of the Wasatch Mountains." From this last locality Mr. H. Schoemaker had forwarded to Cope a collection of fishes, leaves and insects. No mention of the Twin Creek locality was made in these earlier papers. It was discovered between the time of publication of these early papers and the great "Bible," or else this name was given to the locality above cited as "near the main line of the Wasatch Mountains."

The Twin Creek locality has been the source of most of the fishes collected since



Photograph by R. Moore

FIG. 1. FISH CLIFFS, ONE MILE NORTH OF FOSSIL, WYOMING.

THIS IS THE TWIN CREEK LOCALITY OF COPE. THE CLIFF IS ABOUT SEVEN HUNDRED FEET HIGH, THE FISH LAYER IS JUST ABOVE THE DARK BAND TOWARD THE TOP.

the 1870's. Here both scientific and commercial collectors have been working since 1880. The main locality is at "Fish Cliffs" (Fig. 1), on the north side of Twin Creek Valley, one mile north of Fossil, Wyoming, a station on the Oregon Short Line Railroad. Other localities have been worked around Fossil, and much material has been obtained, but the preservation of the fishes, at least, is seldom as good as at Fish Cliffs.

The section of Green River shale exposed in Twin Creek Valley is about seven hundred feet thick. Toward the top it grades into a brownish zone, less resistant to weathering, which rounds off the top of most of the bluffs of the more resistant oil shale. The fish layer on Twin Creek is about fifty feet below the top of the main bluffs, in the typical part of the section. It is a bluish-white marl, thin-bedded, brittle and not the higher grade oil shale found throughout this formation. Its total thickness is near one foot, and it is divided into a four-inch and an eight-inch member by a thin seam of oil shale.

The method employed by collectors working out a part of this layer is a simple one. A quarry site is carefully chosen, it must be bounded on either side by "settling cracks" which divide the entire face of the bluffs into units of varying size. The layer itself between the settling cracks must show joint cracks clearly, from two to four feet apart. The large settling cracks determine the size of the quarry, and since there is a slight slope to the bluffs, by starting thirty or thirty-five feet above the layer and removing the shale between the settling cracks, a considerable area of the fish layer is exposed. The over-burden is blasted and moved away by hand. Several layers of fishes are encountered, but they are poorly preserved and rotten. One layer seems to be made up of loose scales.

After the fish layer is cleared of overburden, the joint cracks prove their value. They enable the collector to raise the stone between them in blocks not too large to handle. Once the slab is raised and resting on saw-horses, a line of thin chisels is driven into one end of the slab to split it in half. No matter how thin the slabs become they are "halved" if possible. Seldom are the fishes found directly on the bedding planes (along which the rock cleaves) but lie between them covered by a thin film of matrix. The "shadow" of dim outline of the vertebrae and caudal fin may be seen, but an experienced eye is much quicker at this than an amateur.

Once specimens are seen, and they are likely to be numerous, the slab is sawed into convenient sizes for handling with as little damage to the material as possible. The commercial collectors carry the slab down off the cliffs and put them in storage, to be worked out during the winter when the inclement weather prevents activity in the quarries. In the preparation of this material the commercial collectors use an ordinary pocket knife with a rounded blade point and sand paper. Most any museum contains specimens of their skilful workmanship.

Seldom has this quarrying been more than a one-man job, the usual rate is one quarry opened and cleared out in the four summer months.

The most common fishes are those of the genus *Diplomystus* (Fig. 2), a small herring. These are from two to twenty inches long, and the five- to seven-inch size sell for one dollar and fifty cents to three dollars. It is often possible to obtain several of these on one slab; as high as twenty-four fishes have been developed on slabs of less than one square yard. The small *Priscacara serrata* (Fig. 3) is the most popular and easily salable of all the types of fishes collected here.

Under the name "Sun Fish," five- to seven-inch specimens bring from two to five dollars. Members of this genus are less common than the Diplomystids, and the smaller sizes tend to occur in "schools." Certain quarries will contain many hundreds of them, while in others they are relatively few. *Pharodus* (Dapedoglossus), a deep-bodied fish with many circumorbital plates, is also fairly common among the larger fishes. Small specimens of this form, twelve to twenty inches long, sell for fifteen to thirty-five dollars; but the still larger specimens run as high as one hundred dollars. The other genera of this fauna are less common, especially the larger sizes. However, every quarry furnishes these in some quantity. The fresh-water sting-ray and the large garpike from these beds are rare. If one specimen of either form is encountered in a quarry, the excavator considers himself lucky. The other elements of the fauna (birds and reptiles) are so rare that probably less than five specimens have been discovered.

The market for these specimens is largely through curio dealers all over North America. Some material is sold to passing tourists and to commercial fossil collectors. Many years ago specimens were sold on the depot platform at Green River, Wyoming. Fifty cents to a dollar and a half covered most of the fishes sold in this manner. Very few specimens are purchased by museums or other scientific institutions. The market is never "flooded," since only a few people are collecting at a time. Many of the specimens are cemented into fireplaces, or used in other decorative ways; a few ultimately find their way into museums.

The most persistent collectors of this material have been Mr. Haddenham, of Kemmerer, Wyoming, and Robert Lee Craig, who is now in retirement. Both these men have worked the Twin Creek exposures for the last forty years. The "Fish Cliffs" are on public lands, and attempts to homestead or purchase the locality have been side-tracked. Apparently it is the intention of the land office to keep the land open so that any one may collect there. It is possible that the area may be made a state park in the future.

Fossil fishes are found scattered throughout the entire Green River

FIG. 2. *DIPLOMYSTUS ANALIS.*
MEMBERS OF THIS GENUS ARE THE MOST COMMON OF ALL FISHES IN THE GREEN RIVER SHALES. THEY RANGE IN SIZE FROM TWO TO TWENTY INCHES; THE ABOVE SPECIMEN IS ABOUT SIX INCHES IN LENGTH.

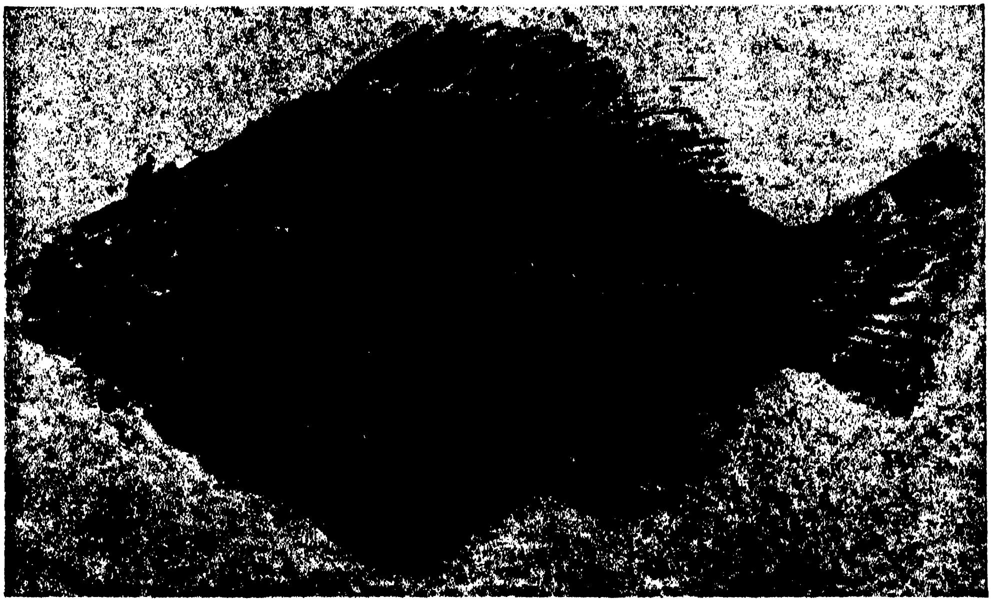


FIG. 3. *PRISCACARA SERRATA*, A CICHLID FISH.
ONE OF SEVEN SPECIES FOUND IN THE GREEN RIVER FORMATION. THESE FISHES RANGE IN SIZE FROM THREE TO TEN INCHES, AND ARE THE MOST SALABLE OF ALL FORMS FOUND THERE.

formation, but so far as known the above localities are the only ones which have produced abundant material. How, then, may the deaths of countless numbers of fishes, at more or less regular intervals, over a great period of time, be accounted for? The sediments of the Green River are, in part, volcanic, but the deposition of this volcanic material was in no sense cataclysmic. There is little to indicate that there were any ash falls, seemingly the volcanic material was more in the nature of dust. The even, laminated deposition of the beds does not suggest that the fishes were suddenly overwhelmed by terriginous matter, such as might occur in times of flood. Nor is there any sign, in the specimens themselves, that might indicate struggling accompanying a violent death.

Bradley, in discussing the varves of the Green River formation, has brought out the high organic content of the sediments of this formation. This organic matter passed through a stage of putrefaction, analogous to the black fetid organic oozes now forming in both fresh- and salt-water lakes. That annual deposits of this organic matter were laid down seems to be proven beyond doubt. Possibly the fishes were killed by the fouling of the water due to dead plankton and algae. Any home aquarist is familiar with the danger of "green water" suddenly turning brown, a change that may take place in a few minutes, killing all the fishes in the tank.

Some such explanation as this seems logical to the writer to account for the Green River fish layer. However, the varves extend throughout the entire two thousand feet of the formation, while the fish layer is only fourteen inches thick, near the top of the section. Nor is that layer seemingly one rich in organic matter derived from the sapropel. Why fish layers are not common in the entire section I am at a loss to explain.

INSECT GALLS

By CHARLES I. LONG
LOS ANGELES, CALIFORNIA

INSECT galls, although more common, are so inconspicuous as to be almost as hard to find as honest men. They are odd and often beautiful growths on plants and trees caused by any of a number of tiny insects known collectively, although rather unscientifically, as gallflies. The commonest of these gallflies are gall-wasps (Cynipidae), gall-gnats (Cecidomyiidae) and aphids (Aphidae). Aside from these, certain mites, sawflies, thrips, caterpillars and chalcis flies occasionally cause them.

A typical gall, such as the oak apple, is formed in the following manner: A female gallfly selects a suitable plant and punctures the epidermis of a developing leaf or bud with her ovipositor. In the hole thus made she deposits an egg. Shortly afterward the egg hatches into a minute grub, which starts to feed upon the plant tissues surrounding it. The cells in these tissues become extremely viable, and, increasing rapidly, must of necessity bulge out in one way or another. Soon the grub is completely enveloped by a structure that may be almost any shape and often of considerable beauty.

COMMON OAK APPLE

A TYPICAL GALL, FOUND ON THE LEAVES OF THE RED OAK IN MAY AND JUNE. CAUSED BY THE GALL-WASP *Amphibolips confluentus* HARR.

Within this protective and nutritive prison the larva feeds and grows, sometimes for days, sometimes for weeks or even months, and there is often a definite correlation between the length of the larval stage and the life of the gall. After the period of pupation, the larva, now a matured insect, chews its way to liberty with its saw-like jaws.

This, briefly, is the story, but it has many variations. For instance, not all gallflies have jaws with which to bite their way to freedom, and the means by which they circumvent this handicap is often amazing. In the case of aphids, whose mouths are fitted only for imbibing liquids, the predicament is solved by natural openings in the galls through which the mature bugs can emerge by the simple expedient of walking. A quite different condition obtains among some gall-gnats, whose pupae are provided with spines to function in boring a hole to the surface. The origin of such timely and adequate structures for an emergency occurring only once in the life of the insect is a drama in itself. In still other cases, galls rupture at precisely the time the mature gnats are ready to leave. Without such provisions as these, galls would become lethal chambers for their helpless prisoners. In remarkably few cases, considering that it would seem the

easiest method, the larva eats its way out of the gall and pupates on the ground. One would expect to find mandibled larvae of all helpless gnats doing this instead of waiting until, during metamorphosis, they lose their jaws and become dependent upon the rupture of the gall or the development of pupal spines or some other such makeshift, to provide a means of escape. But then, one has reason to expect many things that never happen.

The origin and evolution of the adaptive cooperation between insect and plant is a problem to stir even the slowest imagination. By what accident was the gall-forming habit first hit upon in the life cycles of such diverse insects as wasps, gnats, aphids and moths? How does it happen that solid, woody galls with no natural outlets are associated with insects having some sort of gnawing apparatus, while those of helpless aphids have natural openings, or accommodatingly form them at the proper time? What causes galls to form in the first place?

The questions of the why and wherefore of a gall's formation have long been matters of conjecture, but the researches of biologists have gradually cleared away much of the fog surrounding them. Some galls presumably are caused by a minute drop of poison injected into the plant by the female insect as she lays her egg. This causes a sudden, rampant growth of the always active cambium and parenchyma cells and a consequent enlargement comparable in some ways with the swelling caused by a mosquito bite or bee sting. Moreover, since each species of gallfly causes a characteristic gall, it has been supposed that this is analogous to the fact that fleas, wasps, bees and other insects produce characteristic swellings on people, the chief difference being that in the case of such stings no egg is present. Evidence to support this theory is found in the fact that all hymenopters (a group including gall-wasps) possess a poison-secreting gland in close proximity with the ovipositor. It would seem, therefore, that the specific stings of the different species of insects might cause equally characteristic galls. It is hard to prove this, however, if for no other reason than the fact that the virus is secreted in such minute quantities that chemical analysis of its composition and effect is almost impossible.

On the other hand, most galls do not begin to form immediately after the egg is laid, but wait until the larva has hatched and begun to feed upon the plant tissues surrounding it. In this case it is doubtful if a poison could be the cause. Moreover, there are plenty of gall-producing insects which do not secrete a poison sting. This indicates that, in such cases at least, it is the movements and secretions of the growing grub, a constantly renewed chemico-frictional stimu-

OAK SEED GALL

ONE OF THE MOST BEAUTIFUL OF OUR NATIVE GALLS. ON THE WHITE OAK IN JUNE. CAUSED BY GALL-WASP *Andricus seminatus* HARR. A COMPACT WAD OF GLISTENING WHITE FIBERS ENVELOPING A GROUP OF SEED-LIKE LARVAL CHAMBERS WITH HARD, STRAW-LIKE WALLS.

POINTED BULLET BALL

A VERY COMMON GALL GROWING SINGLY OR IN CLUSTERS ON THE TWIGS OF THE SWAMP WHITE OAK. IT IS HARD AND WOODY, WITH A LARVAL CAVITY IN THE CENTER CONTAINING A WHITE-SHELLED OVAL STRUCTURE IN WHICH THE LARVA LIVES. CAUSED BY GALL-WASP *Holcaspis duricaria* BASS.

lus that initiates the odd formations we see (but more often do not see) on trees and lesser plants.

It is probable that both of the above explanations are true in their respective cases and that galls are the result of several contributing causes rather than any single one. The second process is known to be true in most instances and is indisputable where the gall-producing insects are definitely known to be devoid of the virus-secreting glands. But there are still other factors that can not be overlooked. For example, some galls do commence to form almost as soon as the egg is deposited, even though no poison is present, and, since the egg swells after being inserted into the plant, its pressure on the surrounding tissues may be the initial stimulus to gall formation. This would not account for the specific differences in galls, however.

The correlation between the structure of the gall and of the insect is understandable on the theory of natural selection, in so far as galls providing no egress to jawless insects would inevitably weed out the failures as they arose; failures, that is to say, in producing open-mouthed galls or pupal structures to cope with the problem of solid galls. It is probable, for instance, that for every species of jawless insect whose life history involves a gall with a natural opening, countless other species have at some time in the geologic past attempted similar ventures with disastrous results. Those which evolved the device of pupal spines doubtless suffered an even greater weeding out. Those galls which are more or less solid, with no natural openings, but which

OAK PETIOLE GALL

A COMMON GALL CAUSED BY THE GALL-WASP *Andricus petiolicola* BASS. THE ILLUSTRATION SHOWS HOW THIS TYPICAL GALL RESULTS FROM THE CONVERSION OF ORDINARY LEAF TISSUE INTO A SOLID, WOODY STRUCTURE CONTAINING MANY LARVAL CHAMBERS.

rupture or disintegrate at the time their jawless gnats are ready to emerge, almost suggest design as an explanation for the opening of prison doors at the crucial moment. Such timing seems too accurate to be accidental. But the answer is to be found in the physiology of a gall. As long as the larval secretion continues, the cells of the plant will be stimulated, but when at pupation these secretions and excretions cease, the plant tissues are no longer stimulated. Their viability quickly wanes and growth ceases altogether, for the sap channels are completely disorganized in a gall. Thus the once abnormally active cells wither and split apart. By this time the gall-gnat larva has completed its metamorphosis, and wakens to find an unimpeded passage into the world of love and sunlight. The evolutionary implication is that selection has been in the direction of adapting the pupal stage to the length of time required for the active gall tissue to disintegrate.

HICKORY ONION GALL

CAUSED BY THE GALL-GNAT *Cecidomyia holotrica* O. S. ONE OF THE COMMONER GALLS FOUND ON THE LEAVES OF HICKORIES IN MID-SUMMER.

HICKORY LOUSE GALL

CAUSED BY *Phylloxera caryaecaulis* FITCH. A TYPICAL EXAMPLE OF AN OPEN-MOUTHED APHIS GALL. IT IS A DISTORTION OF A BUD.

The reason why jawed insects such as gall-wasps produce structures with no natural openings is not so easy to answer, for there would appear to be little advantage gained except, possibly, greater protection from enemies, rain and the rigors of winter. These advantages may be more important than we suppose, however, for it is true that by far the greater number of galls are produced by these mandibled insects, and they are almost always devoid of natural openings.

A surprising feature of many galls is their dissimilarity from the parts of the plant upon which they occur. So great is this that they often appear to be foreign parasitic bodies adhering to a leaf or twig, and not merely modifications of those parts at all. Their appearance is in the nature of a biological caricature, however, for they are disproportions and exaggerations of fundamental parts of the plant, just as moles on human beings are scarcely recognizable modifications of

ordinary tissues. A gall is a leaf gone wrong, a twig that has run amuck, a bud that has defied its destiny.

Most galls are associated with gall-wasps of the large family Cynipidae. These insects rarely exceed a sixteenth of an inch in length, and range in color from red to orange, and from blue to green and black. Their mandibled mouth is fitted for gnawing, and is used to advantage in releasing the imago from its gall. The adult wasps apparently require no food, although they have been known to take a sip of water.

Most gall-wasps prefer oaks where they deposit their eggs in the leaves, bud or stems with a proportionately long ovipositor. The egg has a thread-like appendage called an egg-stalk reaching to the top of the hole apparently functioning as an air tube. The stalk is longer or shorter in proportion to the depth at which the egg lies in the puncture.

FLAT WILLOW GALL

CAUSED BY THE SAWFLY *Nematus desmiodes*. THE LEAVES OF THE SHINY WILLOW ARE OFTEN HEAVILY BURDENED WITH THESE FLAT, SOLID GALLS.

HICKORY CONE GALL

NOT UNLIKE THE ONION GALL IN SHAPE, BUT DEVOID OF THE BROWN PUBESCENCE CHARACTERISTIC OF THAT GALL. AT FIRST IT IS PALE YELLOW, BUT LATER BECOMES RED OR VIVID BEET PURPLE, FINALLY TURNING BROWN AT THE END OF THE SUMMER. CAUSED BY THE GALL-GNAT *Cecidomyia sanguinolenta* O. S.

The minute, delicate gnats of the family Cecidomyiidae also produce galls. These insects sometimes attack annual plants, a departure from the usual habits of gall producers.

A few aphids cause galls which are due, apparently, to the excretions of the mother bug. The gall grows about her, and in it she gives birth to young, instead of laying eggs like ordinary insects.

Parthenogenesis, or virgin birth, is not confined to Christian mysteries, for it is not an uncommon occurrence among gall-producing insects, especially gall-wasps and aphids. In fact, generation after generation of certain species of gall-wasps have been bred under laboratory conditions with never a male appearing. In other species both males and females emerge from galls in the summer. These

BLACKBERRY KNOT GALL

A LARGE, LUMPY, DEEPLY FURROWED MASS OF JUICY PITH WITH MANY FAIR-SIZED LARVAL CHAMBERS, CAUSED BY THE GALL-WASP *Diastrophus nebulosus* O. S. A VERY COMMON GALL, AND ONE OF THE FEW THAT IMPAIR THE VITALITY OF THE PLANT, ALL PARTS ABOVE IT DYING, BUT NOT UNTIL THE GALL ITSELF HAS BECOME BROWN AND WOODY IN THE AUTUMN.

mate, and the females lay their fertilized eggs, causing more galls that remain over the winter. From these eggs only females hatch in the spring. These virgin females nonchalantly lay eggs without ever seeing a male of their kind, for there are none. Moreover, the galls of this asexual generation are totally different from the ordinary ones caused by fertilized females. The unromantic matriarchy is interrupted when the spring brood hatches in the summer, completing the cycle with a generation of both males and females. Sometimes many male-less broods will follow each other before a bisexual one occurs, and when this happens the galls do not differ from one generation to the next until the asexual spell is broken.

Such parthenogenesis seems incredible to people who dogmatize from the doings of mice and men, but among invertebrates it is not an uncommon occurrence. Actually it is not as miraculous as it may appear, for it involves nothing more than the failure of the ripening egg cells to divide the number of their chromosomes in half. Since the ripened eggs contain the full complement of chromosomes instead of only half, as is the case with most animals, there is no need for mating between male and female. Thus the gall-flies solve the problem of asceticism.

More galls occur on oaks than on any other single group of trees. As many as ninety or more have been found on one species alone, and most of them are caused by gall-wasps.

Hickories also are prone to mold their leaves and stems into galls, and do so from spring until autumn. The greater number of these oddities grow upon the leaves, and few of them are of any con-

GRAPEVINE TUBE GALL

A RATHER RARE GALL CAUSED BY THE GALL-GNAT *Cecidomyia viticola* O. S. THE SURPRISINGLY TOUGH EPIDERMIS SURROUNDS A BROWNISH, JUICY AREA, IN THE CENTER OF WHICH IS A MINUTE HOLE CONTAINING AN ALMOST INVISIBLE LARVA.

siderable size. The most conspicuous, though not necessarily the commonest, are those of the aphids, growing as large as a nut upon the stems, or developing into warts upon the leaves, assuming a variety of shapes and colors. A single tree will often produce as many as five or six different kinds of galls and in great profusion. Many of the leaves will be thickly dotted with the strange little growths, and the terminal twigs will be heavily burdened with leathery tumors.

There are more than fifty described kinds of galls on willows. Most of these are formed by gall-gnats, although some are caused by mites and sawflies. They usually occur upon the leaves of the bushy willows.

Many other kinds of trees have their characteristic galls. The basswood grows pallid warts on its leaves, the alder reconstructs its bud, and the honey locust turns its leaves into pods. The pitch pine and balsams modify their terminal twigs, and the cypress contrives miniature pineapples. The dogwood, wild cherry, tulip tree and ash all produce galls freely, as do the maples, poplars and witch hazel. On the other hand, the horse chestnut rarely if ever produces one.

There are scores of plant galls, some of them too small to be noticed, while others are too large to escape the attention of any but the blind. The goldenrods are particularly prone to such deformities, and the bulges on their stems are a common sight on any walk in the fields. Loosestrife is another plant that is commonly galled, and grapes, poison ivy and wild lettuce all have their characteristic tumors. A host of other plants develop galls, but they do so either less commonly or less conspicuously. For instance, a gall is rare on the black-eyed Susan, while the bulge on the false indigo stem, although common, is less often found because it is insignificant and hidden among the foliage. Few galls on annual plants are made by gall-wasps, but many are made by gall-gnats.

The rose family is peculiarly susceptible to the gall impulse, and yet in some regions very few rose-galls can be found. Not only wild roses, but also the blackberry, raspberry and cinquefoil, all members of the same family, produce these structures.

One never knows what is in store for him when he hunts for galls. I thrilled one time with the discovery of what I knew must be a new and rare specimen, for there, hanging from the leaf-stalk of a hickory sapling was a furry growth as large as a lemon, and quite different from anything described in any work on galls I had ever studied. But just as I was about to examine it, it sleepily lifted its head, half opened its beady eyes and flew away. My gall was a little bat!

FRESH-WATER AQUARIUM FOR MUSEUM USE

By CLIFFORD B. MOORE and FRANK D. KORKOSZ

SPRINGFIELD (MASS.) MUSEUM OF NATURAL HISTORY

Springfield, Massachusetts, a city with a population of 150,000, is much too small to possess a large independent aquarium building as in the case of New York or Chicago. Nevertheless, in planning for the new addition to the Museum of Natural History, formally opened late in 1934, a compact unit of fifteen exhibition tanks of 300 to 800 gallons each, together with storage reservoirs having a total capacity of 10,000 gallons on a gallery of its own overlooking the Hall of Marine Life, was provided for.

One of the outstanding features of this aquarium is its adaptability to the limited amount of space available in a single long room, 12 feet by 68 feet, including the long public gallery. That discouraging aspect of aquarium maintenance, the breakage of plate glass, has been entirely eliminated by casting each plate of the inch-thick, rubber-lined glass into a heavily all-welded galvanized iron frame, outside the concrete tank. This arrangement takes care of all undue tensions and strains to which ordinary aquarium glass is subject.

The inside of each concrete tank was neutralized and solvent materials removed by washing and soaking with phosphoric acid over a period of six months. Then the concrete was impregnated by blowtorch with hot paraffin, such treatment making it in many ways equivalent to an all-glass tank.

The water bill for the Springfield Aquarium is nil, for the reason that the water in the tanks is used over and over and the amount lost by evaporation and other means is replaced by pure and well-aerated rainwater drawn from the roof and stored in three large reservoir-tanks.

Replacement of water within all fifteen tanks goes on continuously, the "used" water being pumped up and passed through two filters where the larger impurities and foreign matter are removed as they pass through the gravel and bone-char medium. The water continues through the pipe lines and is distributed among the three large storage tanks where it stands with a large surface area exposed to the air, and in addition, receives much aeration from the luxuriant growth of aquatic plants within these tanks, thus adding to the oxygen content of the water and completing the factor of balance. Leaving the storage tanks, the pure and aerated water is splashed from taps at a height of six inches into the individual tanks. To meet the extra oxygen requirements of the brook trout, coming as they do from highly aerated, spring-fed brook waters, an auxiliary pipe, punctured with holes, has been set up about a foot above this tank and 30 separate jets of water steadily played on the water surface of the tank.

Care has to be exercised in the collecting of rainwater used in replenishing that water lost in circulation. It is after several hours of steady precipitation that the valve admitting the rainwater from the roof is turned on and the water allowed to pass into the two auxiliary storage reservoirs under the corridor flooring, and this only after pH and sediment tests. Most of the impurities, such as dust particles, cinders from neighboring chimneys, etc., will have been washed away, and by the steady downpour, the rainwater caught will be comparatively free of toxic and foreign matter. The smaller auxiliary tanks are

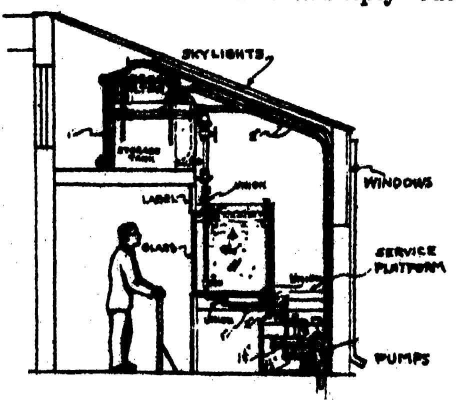
ALONG THE PUBLIC GALLERY OF THE AQUARIUM

OVERLOOKING THE HALL OF MARINE LIFE OF THE SPRINGFIELD MUSEUM IS THE ROW OF FIFTEEN EXHIBITION TANKS CONTAINING TWENTY-THREE DIFFERENT SPECIES OF NATIVE FRESH-WATER LIFE, FROM BROOK TROUT TO FROGS AND MUDPUPPIES.

connected directly with the larger reservoirs, and the rainwater is in turn mixed with the aerated water in them.

Brass pipes and fittings such as contribute to the toxicity of water are not used, but rather galvanized iron piping. In view of keeping so many different species of fish and pond life in the same water it has been found best to keep the pH at 6.8. Samples of the pH of pond and river water from which new fish come is always made and the pH of the aquarium water is brought over to duplicate as nearly as practicable the pH of the former. If it is to be raised on the alkaline side, sodium bicarbonate is the agent used, and if it is to be lowered to get an acid reaction, sodium phosphate. All new fish before being introduced to the tank containing healthy life are quarantined for a period of observation in a well-aerated and separate tank beneath the corridor floor. The chemical germicidal agent used to combat bacteria and other parasitical organisms in this tank is potassium permanganate and salt.

Very little heat has to be manufactured for the aquarium during the winter months. In the first place, the aquarium is built on a gallery three floors up, with heated air rising continuously from the first two. Steam radiators are diverted and made to heat the outside walls of the two pump tanks. Thus the water in circulation may be heated to any desirable warm temperatures by simple adjustment of a thermostat. When it is desirable to sterilize and clean the entire aquarium pumping system, the water can be completely drawn off and live steam sent through the entire length of all pipes and up through the pumps and filters. The steam-pipe lines entering the museum building from the adjacent central heating plant are laid for fifteen feet under a flower bed and the heat furnished the surrounding soil in winter enables earthworms to live and multiply out-



CROSS-SECTION OF SPRINGFIELD AQUARIUM

ECONOMY IN THE UTILIZATION OF SPACE WAS FOREMOST IN THE MINDS OF THE DESIGNERS OF SPRINGFIELD'S AQUARIUM. ALL MECHANICAL UNITS AND INSTALLATIONS ARE EASILY ACCESSIBLE AND SO LOCATED AS TO ALLOW BOTH FREE PASSAGE ALONG THE CORRIDOR AND UNOBSTRUCTED OBSERVATION FOR VISITING BIOLOGY STUDENTS FROM NEIGHBORING EDUCATIONAL INSTITUTIONS.

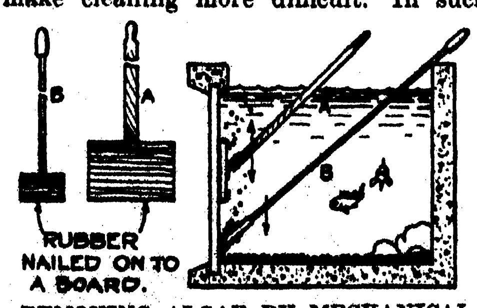
doors. The winter worm supply for smaller fish, turtles, crayfish and other forms is thus conveniently dug here at all times.

The normal water temperature in all the aquarium tanks is kept from 60° to 65° F. at all times, and that of the trout tank at 58°. Normal spawning and egg laying takes place at these temperatures.

To maintain lower water temperatures during the summer months, an old electrical commercial ice-making unit with a capacity for 900 pounds of manufactured ice every 24 hours, was installed and maintains the proper summer water temperatures.

Alga growths and bottom refuse is removed from the tanks by that efficient scavenger, the common sucker; also from the bottom by rubber suction tube; and from the glass front by a special rubber-ridged, long-handled cleaning device. The bottom of each tank is cleaned by siphoning, an hour after daily feeding to prevent the water from becoming fouled.

It has been found that in the case of the tanks with fish not having the sucking-mouth adaptation, gravel is unnecessary on the bottom and tends to make cleaning more difficult. In such



REMOVING ALGAE BY MECHANICAL MEANS FROM THE AQUARIUM TANKS

THE CORRUGATED RUBBER ON ITS FRAME IS ATTACHED TO LONG HANDLES WHICH ARE MANIPULATED BY HAND IN AN UP-AND-DOWN MOTION. A IS SET ON HINGES AND ALLOWS FOR MUCH FREEDOM OF MOVEMENT, WHILE B IS RIGID THROUGHOUT AND IS ESPECIALLY SUITABLE FOR GETTING AT THE CORNERS AND AREA CLOSE TO THE BOTTOM.

THE EXHIBITION TANKS OF THE MUSEUM TAKEN FROM "BEHIND THE SCENES"

THE THREE LARGE RECTANGULAR TANKS UNDER THE SKYLIGHTS DO THREE THINGS: HOLD THE FILTERED WATER; RECEIVE NEW RAINWATER; AND BY THE AQUATIC PLANTS WITHIN, AERATE IT.

cases, the gravel layer has been dispensed with, except perhaps for little banks along the front; this for the esthetic effect. The two filters are cleaned by reverse pressure or by having city water backwash through them, this being done monthly.

The food bill for the entire community of aquarium inhabitants seldom reaches 75 cents a day. This expense item is divided between the purchase of liver, beef, pig's heart, fresh smelt and other raw meats from local fish markets. A special state fishing permit enables the museum aquarist to journey a few miles up the Connecticut River from time to time and obtain a supply of live shiners, small fish which are fed regularly to the pickerel, bass and perch. Prepared and

commercial fish foods are not used in the Springfield Aquarium because of unfortunate experiences in the past involving the introduction of disease conditions.

To achieve a well-balanced display in each tank, the aquatic life is at present being studied and rearranged. In each tank it is hoped to have a non-combative species of fish, one which is a bottom habitué. For instance, suckers and catfish are bottom denizens, while sunfish, perch and carp are what is known as "higher-ups."

In determining just what forms of aquatic life and species of fish to display in the Springfield Aquarium, both the interests and needs of the public were taken into serious consideration. It is the avowed purpose of the museum to acquaint the public first of all with local forms and to stimulate an active interest in the life habits and characteristics of such. For this reason, all local freshwater life from eels, mud-puppies, pond turtles, frogs and crayfish to tiny Johnny-Darters and large and voracious bass are on exhibition under artificial aquarium conditions which duplicate as nearly as possible actual stream conditions from which they originally came. Most every one goes fishing some time in their life in their own local waters and to see the kinds of fish one can hook; besides, labels which elaborate briefly on their life habits means much in the individual's reaching a better understanding of aquatic life and consequently away from the confusion which so often arises in the identification of fish forms in the field. Incidents like the following impress the museum staff with the usefulness and practicability of the institution's plan. The other day a devotee of the art of Walton, rigged in heavy rubber boots and complete angler's attire and carrying his fishing rod, entered the museum and aquarium gallery, made a rapid and thorough survey of the different fish and was off again. As he remarked to a member of the staff stationed on duty on the exhibition gallery, he just wanted to renew acquaintance with the tank inhabitants and get an idea of the fish he expected to encounter on his trip.

THE MALE BIRTH SURPLUS

By DR. HEINRICH ROSENHAUPT

FORMERLY DIRECTOR OF THE MUNICIPAL HEALTH BOARD OF MAINZ, GERMANY

IT is a well-known fact that of all the children born into the world alive the males exceed the females, roughly speaking, in the ratio of 106 to 100. It is often stated, and almost as often disputed, that after great catastrophes, such as wars, in which the lives of many men have been lost, the relative proportion of male births reaches a still higher figure. Statistics of the years following the great war seem to prove the truth of this assertion.

Not more than 200 years ago Johann Peter Süssmilch, theologian and statistician, wrote a book on the "Divine Dispensation in the Variations of the Human Race, proved by Births, Deaths and Reproduction." In the remarkable phenomenon of the increase of male births after periods of catastrophe he saw the hand of Divine Providence interfering to make compensation for the afflictions of mankind brought by war and pestilence. No such explanation as this can, of course, satisfy us to-day. For us the whole world order is bound to everlasting laws, and it should therefore be our endeavor to seek explanations of universal scientific validity for the variations in the male birth surplus. That is to say, we should try to ascertain what post-catastrophic conditions may lead directly or indirectly to an increase of male births, and how we are to imagine the processes of cause and effect which produce the given results.

But before we proceed to investigate this special problem, we must first recognize another remarkable fact, *viz.*, that while there is universally an excess of male over female births, at the same time the mortality among boy infants so far exceeds that among the girls that at the end of the first year of life there has hitherto generally been a surplus of girls. Moreover, there are two further points to be noted; first, among the still-births the males exceed the females by from 25 to 30 per cent., and, second, that the number of miscarriages of male offspring is almost double that of female offspring.

Christoph Bernoulli (1782–1863), not, like Süssmilch, a theologian and statistician, but a natural philosopher and statistician, already had clear views concerning the problem we are dealing with. We quote his exact words:

> . . . Moreover, we see that, in spite of the excess of male births, before the age of maturity is reached the numerical equality of the sexes is re-established through the male children being subject to a higher rate of mortality. Unmistakable as this reciprocal action and its purpose are, it becomes all the more mysterious why nature should in this way aim at a result which could be directly attained if the conditions of genesis and decease totally disregarded sex variation in the individuals. And in any case this theological purpose throws no light on organic or physiological causes which lead to a more frequent genesis of male individuals. At the most we may infer from the correlation of these two phenomena the existence also of some causal nexus.

And again,

> If in the first years of life more boys die than girls and a still more striking disproportion is found in the still-births (there are far more male embryos than females among the still-born), it can hardly be doubted that still more male than female embryos die before birth, and consequently that the sex ratio of male conceptions is considerably higher than that of male births. Unfortunately we possess no exact data at all concerning the numbers of miscarriages, to say nothing of their sex ratio. Assuming, however, that for every 16 male and every 24 female children born alive there is one case of miscarriage, we should come to the following proportions: 1,000 female births to 1,042

female conceptions, and 1,060 male births to 1,126 male conceptions, and the actual sex ratio of conceptions would be 1,082 to 1,000.

The general truth of these statements has been confirmed by later investigators in the same field. Whether the exact figures have had to be modified in the one direction or the other is of little importance for our consideration of the problem. Looking at the matter from the purely biological point of view, the fact remains that from a high surplus of male conceptions there is still a considerable surplus of males at the entrance into life at birth. With the better attention now paid to prenatal care and infant hygiene we may certainly expect in the future a rise in the number of living males. A female surplus would be quite out of the question so long as no war catastrophes caused a diminution of the male population. Those numerical relations can not be explained from any principle of racial preservation, in other words, from a teleological point of view. For racial preservation an excess of women would be of far greater importance than the reverse relationship.

We shall now try to investigate the biological causes which may account for the surplus of male conceptions and births. Düsing (*Die Faktoren welche die Sexualität entscheiden*) asserted among other things that social conditions compel many women to wait for a long time for their first conception, and that they are thus in a similar situation to that in the animal world resulting from a shortage of grown-up males. "Such mothers of advanced age at their first childbirth consequently (?) produce a large surplus of male children." Others (*e.g.*, Goehlert, *Morel de Viade*) have shown that, in the case of horses and sheep, with the advancing age of the female parent there is a corresponding increase in the surplus of male offspring. A similar result is said to have been observed in the case of American cattle when the parent bulls have become exhausted by excessive service. On the other hand, in herds containing a large number of bulls, which are consequently less overworked, there is said to be a majority of cow calves (Fiquet). Similarly, it is asserted that the female offspring of domestic animals increases in number in proportion to the richness of feeding of the parents. Martegoute has found that the mothers of ewe lambs show on an average a heavier weight than those which give birth to male lambs. Landois, experimenting with many thousands of larvae of the vanessa urticae (small tortoise-shell butterfly) succeeded in breeding males or females at will, according as he fed them well or not. The influence of food on the sex ratio has been expressed in the language of political economy by Ploss in the following concise form: "The male surplus rises with the prices of food."

From the foregoing statements it appears that under certain conditions inferior nourishment may influence the sex ratio in favor of the male sex and that sexual exhaustion may have a similar effect. Possibly this latter assumption may account for the special preponderance of males in the offspring of first births of which we shall have to speak later on. Zappert asserts that very young or very old mothers and also illegitimate mothers bear more boys than correspond to the ratio 106 to 100. We have, therefore, apparently to assume three kinds of "weakening" influences: (1) sexual exhaustion, (2) exhaustion through age, and (3) underfeeding.

Famine-stricken Germany in the year 1918, with its ratio of 108.5 to 100, confirms the truth of the last-named factor. Chronic poisoning may apparently also be booked as a weakening factor, for Bondi quotes animal experiments which show that male parents that have been subjected to alcoholic intoxication and mated with young females bearing for the first time produce mostly male off-

spring of inferior weight. Lenz sets up the hypothesis that the male-determining spermatozoa which contain fewer chromosomes come more easily to fertilization when the sperm cell is injured or the egg cell impaired than the female-determining spermatozoa which are well laden with chromosomes. A French investigator, R. Worms (*La sexualité dans les naissances françaises*, Paris, 1912) has ascribed the surplus of male births as well as the (previously mentioned) higher mortality of male children to unfavorable life conditions of the parents, and, in proof of this, he says that with the general increase of welfare in the nineteenth century the male sex ratio of live-born children sank from 107 to 104, and that of still-births from 150 to 135. In contrast to this, Lenz, on the other hand, in the Handbuch of Rubner, Gruber and Ficker, asserts that in Germany the surplus of boy deaths was lower in the war years 1916 and 1917 than it had been previously. The social hygienist can easily find an explanation for this contradiction. The increased attention given to infant welfare, which had formerly been much neglected but was now vigorously carried on in the years of war and distress, had acted especially to the advantage of the more susceptible boy children, independently of the nutriment conditions of the parents. Moreover, the scarcity of milk compelled the mothers to nurse the children themselves, which meant their rescue from an early death through faulty feeding. During the siege of Paris in 1870–71 the failure in food supply had a similar effect to the benefit of the infant.

An unpublished doctor dissertation by Grünewald, *Die Übersterblichkeit der Knaben im Lichte der Erblichkeitslehre* (The excess mortality among boy children in the light of the laws of heredity), 1923, says, "The determination of sex depends on mendelising hereditary factors in which the female sex is homogamous and the male heterogamous. Consequently some of the recessive morbid heredity factors are as a rule effective only in the male sex, *e.g.*, red and green color-blindness, haemophilia, hereditary atrophy of the optic nerve. These sex-linked recessive hereditary dispositions produce their effect in uterine life and early infancy."

In proof of the correctness of this view concerning endogenous causes and of our remarks on the value of infant hygiene, especially in respect to boy children, we may quote the fact that in the year 1911, as a result of special protective measures taken against the external dangers of the abnormally hot summer of that year, the boy death ratio was successfully reduced below the average of the ten years from 1906 to 1916, *viz.*, from 119.2 to 116.9. Grünewald's further contention that endogenous factors outweigh the exogenous in importance—in support of this he gives a curve according to which the excess mortality of boys is in inverse proportion to the total infant mortality—can only be considered correct if he includes, not only hereditary, but also pre-natal influences among the endogenous factors. But as these latter are also influenced by external factors (food conditions, illness, work), it seems to us that they can hardly be classed among the endogenous factors.

This disagreement concerning definitions or nomenclature is no mere "querelle allemande," but is of importance in connection with the problems of maternal welfare. It is easy to declare ourselves powerless against endogenous factors, whereas we do possess means for directing or modifying exogenous factors. The factors that lead to a post-catastrophic increase in the number of boy births should also be capable of determination by comparing the statistical figures supplied by the nations at war with those supplied by neutral nations. In one of the publications of

the medical section of the Board of Health of the Reich (*Statistische Kurzberichte* XV, *Deutsche Medizinische Wochenschrift,* February 19, 1937) an attempt to do this has been made. Three different periods are compared in Table 1. Only slight variations are apparent.

TABLE 1

Periods	Boy birth surplus In nations at war	Boy birth surplus In neutral nations
1915–18	105.9	106.2
1919–20	107.6	106.7
1921–23	105.8	106.2

One proposed explanation made in the publication mentioned seems to us to be of some considerable importance, though it gives no positive answer to the question at issue, but involves a shift in the formulation of the problem. First births are said to show a relatively larger number of boy births than subsequent births, so that the mass marriages following the end of a war may be a sufficient explanation of the increase in the number of boy births.

Statistics from the United States of America for the two periods 1922–24 and 1927–29 are adduced in proof (Table 2).

TABLE 2

Total number		Ratio of male live births	Ratio of male still-births
First births	135,943	106.11	135.16
Second "	67,452	106.0	135.0
Third "	46,589	105.81	135.14
Fourth " and later	153,365	105.23	136.50

Similarly in Germany in the year 1934, in which the number of first births was specially high, a maximum figure of 106.9 was reached in the male birth ratio for the period from 1922 to 1934. The explanation for this is to be found in the state propaganda for an active population policy by means of government grants of marriage loans.

It must not, however, be overlooked that the above-mentioned theories, according to which male births are to be expected from a "weakened" father, are rejected by some authorities and that Vaerting, for instance, asserts that "every misuse, every overexertion of physical or mental powers on the part of the father" leads to boy death. Further, it is said that in harems, in consequence of the sexual exhaustion of the father, for every hundred girls born there are only 25 boy births! (In regard to this last statement one can hardly suppress the suspicion that an "active" depopulation policy has here cooperated in some way or other with the practice of polygamy.)

Equally contradictory are the statements made concerning the influence of so-called race mixture on the number of boy births. (There seems to us to be no justification for considering this as a purely biological problem. Alone the fact that racial crossings in colonial countries are often associated with very great changes in the social and economic circumstances of the mating parties makes it hardly possible to form any exact appraisement of the biological factor). Against statements from Argentina that pure Italians show a boy surplus ratio of only 100.77, pure Argentinians (surely a racial mixture scarcely capable of exact definition) a ratio of 103.26, and mixtures of the two 105.72, we have Eugen Fischer's statements, who calculates a ratio of 108.1 for pure Boers and 107.6 for Rehoboth bastards (Boers with Hottentots).

An altogether special problem seems to be present by relations among the Jews. Among the orthodox Russian Jews the quota for boy births is said to be very high. For this the explanation is given that religious injunctions forbid sexual intercourse during the first 12 days after menstruation and that in a subsequent conception the ovum involved is overripe and consequently predisposed to produce a male offspring. (Whether

this theory can be maintained in the face of the recent spectrographic methods of Samuels (Amsterdam), proving the possibility of repeated ovulations within a single menstrual period, must be an open question). According to the views of present-day German racial speculators the Jews do not form any real race, but a peculiar kind of racial mixture, so that racial-biological conclusions are altogether to be regarded with suspicion. The hygienist Hueppe says concerning this point that with the Jews religious tradition has taken the place of purely racial heredity and has converted a racial mixture into a national unit in which religious injunctions have developed into the code of social hygiene of a "vital race."

A certain contrast to this is presented by the views found in a publication of over eighty years ago. A Hungarian medical officer, Glatter, in a lecture which contains much else that is interesting also from other points of view, compared the Jewish and the Christian population of a small, but to him well-known, district. He expressly stresses the point that there were no essential differences in the economic circumstances of the two groups. The Jewish population under consideration, which was subject to no migratory influences, numbered 1,952 in the year 1833 and 2,462 in 1856. In the intervening 23 years between these two dates no illegitimate child was born. Wedlock fertility amounted to 3.77 per marriage, compared with 3.93 in the rest of the population. The ratio of boy births was 116 to 100 girl births, while for the rest of the population the ratio was estimated at 105 to 100. Glatter further finds that among the Jews infant mortality was lower and the length of life higher than in other sections of the population. He thinks that these peculiar relationships can only be understood by assuming a racial difference. In regard to the sex ratio, in which we are here specially interested, we must regret with the author of the investigation that he had no statistics at his disposal concerning Jewish still-births in the period investigated by him. But he expressly mentions that contemporary statistics for Prussia show that the ratio of still-births to the total number of births was 1:20 or 1:25, but only 1:40.5 in the Jewish population. He also points out that the Jewish expectant mother takes better care of herself than the Christian mother in the same circumstances. If we assume that prenatal care must act above all in favor of the more numerous, but at the same time more delicate, male embryos—the smaller number of still-births seems to confirm this—there is no need to assume any racial, *i.e.*, biological, difference to account for the sex ratio, but we can find an explanation in the precautions taken against harmful environmental influences.

Dr. Göllner, in the "Reichsgesundheitsblatt" for 1935, p. 980, has also investigated the question of the supposed influence of the Jewish "race" on the sex ratio, particularly in the case of mixed marriages between Jews and Christians, marriages between partners of different racial extraction but of the same religious confession being naturally left out of account in accordance with the records of the marriage registers on which his investigation was based. These have hitherto only noted the religion and not the race of the individuals concerned. In the first place, it is not without interest to note that during the world war such mixed marriages in Germany outnumbered the marriages between two Jewish partners. In 1915 there were 104 mixed marriages to every 100 purely Jewish marriages; in Berlin the ratio was even as high as 115 to 100. The fertility of mixed marriages amounted to 0.8 live births as compared with 2.7 children born alive from pure Jewish marriages. The ratio of boy births was far higher than the

average of about 106, *viz.*, 115 on the whole, 109 with Jewish mothers and even 119 with Jewish fathers. The author raises the question whether a "bastardizing factor" is here at work. The low degree of productivity in these mixed marriages would seem to suggest that among the births the number of first-born was especially large. It has already been mentioned that among the latter the boys were altogether above the average, though the ultimate causes for this phenomenon has not been discussed. These may be of biological, but also of sociological origin. The assumption of the latter seems to be justified when we consider the economic circumstances of the Jewish-Christian partners. Whether the difference in the two categories, Jewish father or Jewish mother, has any connection with the lower fertility of one category or with different social combinations, it is difficult to say.

Max Marcuse considers that mixed marriages in which the father is Jewish are often the outcome of previous so-called "Verhältnisse" (irregular sexual partnerships without marriage), and the assumption suggests itself that after a long prenuptial period in which contraception has been practised there is consequently no great desire for offspring in the succeeding period of wedlock. Mixed marriages in which the mother is Jewish, on the other hand, are not seldom money matches, in which these influences may be assumed to have less decisive weight. (Moreover, in marriages of longer duration there are probably many cases in which one copartner has adopted the religious confession of the other and subsequently born children are consequently not registered as the offspring of a mixed marriage, and the boy birth surplus wrongly appears so high). In both the fore-named cases the low degree of fertility registered naturally makes the proportion of first births and consequently of boy births appear larger; among the children of Jewish fathers in marriages of probably still lower fertility the quota of boys must accordingly be especially large. The assumption of "inadequate mixture of germs" seems to be altogether beside the mark, since sociological reasons can be found for the peculiarities of these so-called mixed marriages. The attitude which leads to a limitation of conception is to be found chiefly in the well-to-do sections of society—and it is from them that probably most of the mixed marriages are recruited—but at the same time it is in these sections above all that the desire and the means to spare the mother in the period of pregnancy and to give her all necessary care before, at and after childbirth are to be found. It is therefore not likely that "bastardizing factors" are responsible for a higher ratio of boy births, but rather the effects of the limitation of births and the avoidance of still-births through better maternal welfare. Statistics from America, which we owe to the kindness of the statistician Dr. Louis J. Dublin of New York and which are based on the records of the Bureau of the Census, Department of Commerce, for 1933, give no support for the assumption of a bastardizing factor as tending to raise the ratio of boy births and its effects in favor of a higher proportion of boy births.

To sum up, we come accordingly to the following conclusions:

(1) The post-catastrophic increase in the ratio of boy births seems to be an established fact.

(2) The main cause for this increase must be seen in the preponderance of first births, which in their turn are the result of the accumulation of marriages.

(3) The assumption of racial influences as an explanation for an increase in the number of male births must be rejected; economic and social factors seem rather to be responsible.

(4) On the other hand, it seems to be beyond doubt that maternal welfare be-

fore and at childbirth acts most strongly in favor of the more numerous but relatively less resistant male offspring and therefore must tend to raise the boy birth ratio.

(5) In addition to the measures of maternal welfare, provisions made for better infant welfare likewise tend to increase the number of surviving male infants, so that, in consequence of all improvements in mother and infant welfare together, instead of the former surplus of females a male surplus results. This fact is proved by the latest figures given in the 1937 volume of *Wirtschaft und Statistik*. In 1936 the ratio between the boys and girls alive in Germany was as follows:

Below 6 years, 965 girls to 1,000 boys.

From 6 to 15 years, 969 girls to 1,000 boys.

From 15 to 20 years, 977 girls to 1,000 boys.

There is thus already an increase in the living boys surplus visible within the last 20 years.

MIND IS MINDING

By Professor LESLIE A. WHITE

DEPARTMENT OF ANTHROPOLOGY, UNIVERSITY OF MICHIGAN

We should have a great many fewer disputes in the world if words were taken for what they are, signs of our ideas only, and not for things in themselves.—LOCKE, "Essay on the Human Understanding."

"THE problem of the relation between body and mind has occupied philosophers and scientists since the dawn of thought, and to many it appears no nearer a solution now than then. It has been named the central problem of all philosophy, fundamental alike in the theory of knowledge, in ethics and in religion. Not less fundamental, however, is it for psychology and for physical science. . . ."

These are the opening words of the article "Body and Mind" in "Encyclopedia of Religion and Ethics,"[1] by James Lewis McIntyre, Anderson lecturer in comparative psychology to the University of Aberdeen. Hundreds of books and thousands of lectures and articles have been devoted to the "mind-body" problem. How is it possible for the body to have a mind? How can the mind have a body? Which is the reality, the body or the mind? How are body and mind articulated with each other? These are some of the questions which have plagued us for many a century. And "to many they appear no nearer to solution now than then."

Why has the "solution" not been reached? Where is the difficulty?

It is the thesis of this essay that the "solution" has not been reached because the problem is a false one, somewhat like the paradoxes of Zeno. The difficulty is one of verbal origin; it is of our own making. By rewording the problem the "problem" disappears: use the word mind as a verb instead of a noun and no "problem, fundamental either to the theory of knowledge, ethics, psychology, science" or to anything else, remains. Mind is minding; it is the behaving, reacting, of a living organism as a whole, as a unit.

Once upon a time, in a far-off land, a people was concerned with the problem of Golshok. No one knew *exactly* what Golshok was, but every one agreed that he (she or it) was very important and that their existence and welfare depended in large measure upon Golshok. Many of the best minds of this people devoted

[1] Edited by James Hastings, 1909.

their lives to the study of Golshok. Their lucubrations were recorded and their pronouncements carried great weight. It was decreed that all social life was to be conducted in accordance with the principles of Golshok as set forth by the wise men. Of course it was necessary to put people to death occasionally because of their failure to comply with these principles. This was usually done by burning them alive. This went on for centuries. But not all people were content. Some were bent upon discovering just what Golshok really was—if anything. But they never got any farther than words, save for an occasional burning of a rebel.

Finally some one broke a way out of the impasse. He declared in plain language that the whole Golshok business, from start to finish, was nothing but "words, words, words," that the wise men had been chasing their tails for centuries, with "the solution no nearer now than then." He declared, moreover, that if people would conduct their lives upon human principles instead of Golshok principles they would be much better off.

Of course the wise men had him burned to death and his ashes scattered to the four winds. But they were too late. The secret was out. The common people went around saying, "There ain't no Golshok." And they lived happily ever after.

And so it has been with "Mind." "Mind" is a noun. A noun is a name of something. Therefore there must be something in the cosmos that *is* mind. A person has a mind; it is possible for him to "lose" it. Thus "mind," an entity, a "thing-in-itself," was created and projected into the cosmos. Then people set about trying to find it as they have been searching for truth, the good and beauty, these many weary years. One might as well search the cosmos for $\sqrt{-1}$. Philosophic tail chasing, nothing more.

Organic phenomena are distinguishable from inorganic phenomena: the former have a cellular structure, they appropriate items in their environment and assimilate them into their own cellular structure. Organic bodies move, react, behave. We may distinguish two categories of reactions of living beings—(1) the reactions of parts of the organism with reference to other parts, and (2) the reaction of the organism as a whole, as a coherent unit, to its environment. The reactions of the first category constitute the field of the physiologist; those of the second category the province of the psychologist. The reacting, behavior, of any living organism as a whole, as a coherent unit, with reference to its environment, is minding, or mind.

This commits us to such statements as "An oyster has a mind." Similarly, a paramecium, a radish, a lichen, have "minds." It may sound ridiculous to say that a radish has a mind. But it sounds much less ridiculous to say that a radish *minds*, *i.e.*, reacts to its environment, behaves, does something as a unit. So much are we at the mercy of words that even so slight a change as one from noun-use to verb-use makes the whole world look different. All living creatures possess the property of reacting to external stimuli as coherent, organic units. Mind is coextensive with life.

We come now to kinds of minding, kinds of reacting or types of mind. Obviously organisms behave differently as their structures differ. The mind of man is not the same as the mind of ape or starfish or radish. There are patterns or types of minding or mind, just as there are patterns or types of structure. This does not mean, however, that a classification of patterns of reacting would correspond, point for point, with a classification of structures; classifications may vary legitimately with point of view and purpose. The classification of types of

reaction, of mind, has not been well worked out as yet.[2]

To return to our starting point: what is mind? How can a mind have a body? The solution: mind is minding, the reacting of an organism as a whole, as a coherent unit (as distinguished from the reacting of parts of the organism with reference to other parts). Mind is a function of the body. The "organ" of the mind is the entire organism functioning as a unit. Mind is to body as cutting is to a knife.

But Alexander merely *cut* the Gordian knot; he did not untie it. Neither have we "solved" the mind-body problem, for in the form in which it has plagued the reflecting portion of mankind, it is insoluble. But we have disposed of it. We have not proved, nor can it be proved, that there is no cosmic entity, mind, which has an existence independent of bodies. We have not proved that the "fundamental reality" is not mind, of which bodies are but material expressions. So far as the present writer knows, there is no convincing proof for the non-existence of Santa Claus. Mankind progresses, often, not by disproving propositions but by outgrowing them.

The "Mind-Body" problem is of one piece with the Vitalism-Mechanism controversy. No one has ever "disproved" the theory of Vitalism, but scientists, and many philosophers, are agreed that the time has come when it should be ignored as obsolete, outgrown and, above all, sterile. It is not that the philosophy of Mechanism is True (with a capital T) and that of Vitalism False. It is that Mechanism has been fruitful, productive; Vitalism barren and sterile. Vitalism as "a view is exactly opposite to those which *have led to all the scientific progress that has been made,*" declares Professor H. H. Newman.[3] Biologists have "clung to the materialistic or mechanistic explanation of life, simply because *it was the only way in which progress could be made*" (emphases ours), declares the distinguished paleobiologist, Professor Ermine C. Case.[4] The philosopher Bertrand Russell declares: "To invoke a vital principle is to give an excuse for laziness . . . the opposite view [mechanism] is, scientifically, a more fruitful working hypothesis."[5]

And so, while we have not proved that mind is not some cosmic entity, or proved that it is not the "real reality," we have shown that this view is barren and sterile at its best and confusing and paralyzing at its worst. The opposite view, that mind is minding, or behavior, that mind is a function of the body, releases us from the verbal bondage of a sterile and a paralyzing metaphysics, and sets us free to sow and reap in a field that will bear fruit.

[2] In "The Mentality of Primates" (SCIENTIFIC MONTHLY, Vol. 34, January, 1932) the present writer set forth a brief and preliminary sketch of types of mind. He has since refined and amplified this earlier statement, and plans to publish his results soon.

[3] In an essay, "The Nature and Origin of Life," in "The Nature of the World and Man" (H. H. Newman, ed.), p. 164, Chicago, 1926.

[4] In *The Michigan Alumnus*, p. 3, March, 1934.

[5] "Philosophy," p. 25, New York, 1927.

COMMENTS ON CURRENT SCIENCE

MODERN REFRIGERATION

REMEMBER the ice man? In the pre-war variety he is nearly extinct, but refrigeration is a booming industry these days because of the expanding use of cold-making in food and beverage preservation, air-conditioning and industry. Refrigeration has become one of our complex mechanical industries.

A refrigerating engineer may be called upon to provide anything from ice cubes for a cocktail party to a snowstorm for a movie production. While the electrical or gas household refrigerator, making in your own home its own low temperature, has largely outmoded the ice box, the major task of refrigerating experts may include not ice and low temperature production, but anything that helps preserve foodstuffs or manufacture weather.

At the recent meeting of the American Society of Refrigerating Engineers in New York, American pear growers were advised to adopt the British method of adjusting the atmosphere in cold storage warehouses that allows Bartlett pears to be kept some six months instead of a few weeks. Confirming research at Cornell University shows that the trick is to adjust the carbon dioxide given off by the fruit itself to just the right amount.

Ultra-violet lights are finding their way into cold storage plants and packing houses to kill molds and bacteria that otherwise, even with refrigeration, might spoil the food being stored.

Mass attacks upon bacteria must be used to be effective because it requires 1,250,000,000 average size bacteria to cover an area of one square inch.

One of the most modern methods of food preservation is quick freezing. Extreme chill catches the food before it can change and keeps it fresh for months.

In the research laboratory low temperatures are useful in testing the way automobiles, materials, oils, engines and other useful things react under severe frigid conditions.

The refrigeration industry has come a long way from the days when our grandfathers cut pond ice in winter and stored it in sawdust against the summer's heat.

WATSON DAVIS

SCIENCE SERVICE

PROBLEMS CREATED BY AIR-CONDITIONING

WITH air-conditioning coming into wide-spread use in larger, public buildings, the heating and ventilating engineers who have made this advance in human comfort possible are now faced with some serious problems which they have thus created.

As one example, what health risks are there involved in the recirculation of cool air through a crowded motion picture theater, restaurant or office building? It is hardly economical to use the cooled air only once and take in completely fresh air at each cycle in the air flow. Thus only a fractional part of fresh air is taken in.

Since this situation exists, the question arises whether the bacteria content of the air in an air-conditioned building gradually rises. If it does, does it approach a bacteria concentration which is potentially menacing to health?

In hospitals, too, there is the problem of what to do about the ventilation of contagious disease wards whose air passes into a common system and, potentially, may be recirculated through the whole air-conditioned hospital.

More widely known among laymen is the problem of ridding restaurants and railroad cars of the odor of smoke. Here the problem is complex because it not only involves the cleaning of the air and

its recirculation but the removal of elusive odors.

The research committee of the American Society of Heating and Ventilating Engineers is considering these and other problems. They are formulating experimental projects which will seek the best solution. The task, they well realize, will be slow, for the problems involve medicine, biology, chemistry and physics, as well as engineering.

ROBERT D. POTTER

SCIENCE SERVICE

SCIENTIFIC RESEARCH AND WAR

POTENTIAL war absorbs too much of the world's inquiring brain power to please those who desire more expenditures for making the world a better place in which to live. A recent estimate is that of all the money spent in research in the United States and Great Britain, one fourth goes for military research. The percentage must be even larger in a nation like Germany.

Half of the research money is credited to industrial research and related pure research in physics and chemistry. Even some of this is a military expenditure in the last analysis. Most of the remaining fourth is devoted to agriculture and its supporting sciences. Social and humanistic sciences receive "such an infinitesimal part of the total as to be scarcely discernible!"

In Great Britain, where an articulate group of scientists deplore and expose the "frustration of science," government estimates for 1938–39 show the ratio of 5 to 1 in favor of research funds for military purposes. Admiralty and air ministry research grants total $22,900,000 compared with $4,500,000 for the Department of Industrial and Scientific Research and the Medical Research Council. And some of the industrial and scientific research expenditures are as much for military as for industrial purposes, such as those for aircraft design.

With photographs of destroyed Spanish universities to drive home the point, the science frustration exhibit comments that scientific research to improve warfare is a strange and indirect sort of suicide for the scientist.

In military research the internationalism of the scientist disappears and this contributes markedly to inefficiency. Not only is there no free interchange of information across national borders, but a British commentator says "it is found necessary to segregate the worker from the rest of his scientific colleagues by forbidding mention of his work outside his laboratory."

WATSON DAVIS

SCIENCE SERVICE

DESTRUCTION OF SYNTHETIC CLOTH BY BACTERIA

THE making of synthetic wool-like fibers from the casein of milk is a truly amazing development of modern chemistry. When such fibers are blended with natural wool, beautiful and serviceable fabrics are obtained.

But milk is quickly acted upon by bacteria, and scientists have been wondering if the synthetic fibers too might be susceptible to attack by micro-organisms.

Two Dutch scientists have investigated these "wool-from-milk" fibers and have found that bacteria, which ordinarily are able to destroy proteins of the casein class, succeed in completely dissolving the synthetic fibers. In a fabric made entirely of the synthetic fibers the destruction was complete. In a mixture of 50 per cent. synthetic wool and 50 per cent. genuine wool only the synthetic wool was destroyed.

Jan Smit, lecturer in microbiology at the University of Amsterdam, and his colleague, B. van der Heide, of Wageningen, report to the British science journal *Nature* on their experiments proving these findings.

"It was found," they state, "that nearly all casein-splitting micro-organisms, isolated from soil or manure or gathered by infection from ordinary atmosphere, are able to attack the (synthetic) wool."

The action of the organisms appears to be by means of an enzyme, *i.e.*, by liberating a chemical that attacks the synthetic wool.

Heating the fibers and bacteria to the temperature of boiling water appears to destroy the enzyme reaction so that one might speculate whether wearers of such synthetic wool clothing would have to boil their suits periodically.

However, the destruction is more academic than practical, for it can be recalled that most of the world's buttons are now made of casein and no one worries greatly about bacteria destroying them in actual use.

ROBERT D. POTTER

SCIENCE SERVICE

INSULIN SUBSTITUTES

SOVEREIGN remedy for the treatment of diabetes is insulin, the chemical produced by a group of cells in the pancreas called the islands of Langerhans.

The dramatic story of the discovery of insulin and of the consequent rescue of thousands of patients from both death and a miserable starved existence that made death a welcome release has been told and retold.

Yet stories of insulin substitutes, which can be swallowed instead of injected hypodermically, keep cropping up and arousing hope that all diabetics can keep well without the bother of needle and syringe.

In view of these stories, and to emphasize the fact that so far insulin substitutes to be taken by mouth are only in the hoped-for stage, it might be well to summarize a discussion of the subject by Dr. Hans Jensen, of the Johns Hopkins University, in his recently published book, "Insulin."

Dr. Jensen says that at present there is no substance which is non-poisonous and which can be given by mouth as a substitute for insulin in the treatment of diabetes. A number of substances, he points out, have been found which reduce the amount of sugar in the blood and which when given to patients with mild diabetes have caused a decrease in the sugar in the urine. Yet there are objections to each of them which have prevented their being universally accepted for treatment of diabetes.

The crucial test which an insulin substitute must pass, before being used for treating patients, Dr. Jensen says, is its ability to prevent symptoms of diabetes in animals from which the entire pancreas has been removed. Insulin itself does this.

These remarks on insulin substitutes do not refer to the new, so-called "slow action" insulins, which are prepared from insulin itself but altered so as to prolong the effect of the insulin.

JANE STAFFORD

SCIENCE SERVICE

PROBLEM-SOLVING ABILITIES OF DOGS

DOGS display marked individual differences in "I.Q.," no less than their two-legged lords and masters, Dr. E. G. Sarris, of the Institute for Environmental Research in Hamburg, Germany, has found. Tested by their abilities to solve problems connected with the getting of a coveted piece of meat, their mental abilities ranged all the way from very bright to plain, doggone dumb.

Dr. Sarris started with eight dogs of assorted sexes, breeds and ages. At first he gave them an easy problem, of getting the meat when they were separated from it by a serpentine fence constituting a simple maze. All the dogs could solve that one, though some of them made

hard work of it, while the cleverer individuals went through it very quickly.

Then he increased the difficulties, imposing such brain-puzzlers as getting the meat out from under a can loaded on top with bricks, hauling it over a wall on the end of a string, moving small carts and boxes that would enable them to reach it when it was hung too high for direct approach, etc.

At each set-up in difficulty, some of the animals found the problem too hard and gave it up. Finally, Dr. Sarris was working with his two brightest dogs, a male named Argos and a female named Niki. They could think their way through all the problems he posed them. Of course, Dr. Sarris was careful to devise situations in terms of dog mentality, rather than of human minds.

The Hamburg zoologist believes that practical uses of some importance can be derived from his study. His results, he holds, cast considerable doubt on the universally accepted idea that certain breeds of dog are best for particular working purposes, like herding or hunting. Of far greater importance, he believes, is a dog-by-dog examination for individual differences in learning capacity, based on individual variations in temperament and intelligence.

FRANK THONE

SCIENCE SERVICE

SOUTH AFRICAN FOSSIL MAN-APES

IN 1925 Dr. Raymond A. Dart, of Johannesburg, South Africa, found in a late Cenozoic limestone near Kimberley an incomplete fossil skull of an immature creature which Dr. Hrdlička stated was doubtless *a* missing link, one of the many now extinct forms which bridge the gaps between the present widely diverse families of apes and man. In 1936 a fossil skull and upper teeth of a somewhat similar anthropoid ape were discovered in a limestone quarry near Johannesburg. Professor William K. Gregory and Dr. Milo Hellman, of Columbia University, reported at the meeting of the American Association in Richmond on the conclusions they have drawn from their recent examinations of the teeth of this interesting pre-man, technically known as *Plesianthropus transvaalensis*.

The skull presents such an astonishing mixture of ape and human characters that Drs. Gregory and Hellman were in doubt whether the fossil is that of a very progressive ape or of a very primitive man. The teeth, however, added greatly to their knowledge of the relationship of *Plesianthropus* to other primates. Modern apes use their sharp canine teeth to pierce and tear such things as tough fruits, bamboo shoots and sugar cane, and they cut them into small bits with their characteristic molars. Primitive men, on the other hand, use incisor-like canines to bite into and hold to such softer materials as flesh, and nearly flat-topped molars to grind up flesh, small bones and grains. The teeth of the South African man-apes were intermediate in structure. The gorilla lives almost exclusively on fruits; the abundance of broken baboon skulls in the caves of the man-apes suggests that the latter were eating the brains of the former, perhaps in the first stages in the acquisition of partly carnivorous habits.

Anthropologists have long been puzzled at the many curious anatomical agreements between men and orangs, in spite of their radical differences in locomotion. These investigations suggest that man and the orang may have diverged rapidly and greatly from a more chimpanzee-like ancestor, and that the South African man-apes are late survivors of this early stock. If this conclusion is correct, they are truly related to all the chimpanzee, gorilla, orang and human branches which developed as a result of rapid morphological changes that took place during

periods of vulcanism and glaciation a few million years ago.

F. R. M.

TWO CIVILIZATIONS IN OLD STONE AGE EUROPE

EVEN in the Old Stone Age, Europe was far from simple. This surprising thought is advanced by Professor M. C. Burkitt, Cambridge University archeologist.

Europe, he declares, was nearly as complex in the Old Stone Age as it is to-day. And he is referring to the early part of the Old Stone Age, when we are apt to think of all human beings as dressing alike in skins, sleeping in caves, and spending the days in the same routine of hunting, fishing, eating and pounding out stone gadgets, all more or less similar to the unpracticed eye.

But, as Professor Burkitt surveys the prehistoric scene, he finds that two distinct civilizations can be distinguished, occupying each its own stretches of land in Europe, and also Asia and Africa. The trail of their stone tools, which each civilization made differently, enables Dr. Burkitt to show how the two Stone Age camps stood apart. He believes that they must have been foreign to one another in other ways, but their stone work is the main evidence of their civilization left.

One of these earliest civilizations made tools by chipping flakes off a piece of stone until the core was a serviceable shape. The other civilization adhered to the idea of striking a flake off a stone core, and then finishing the flake itself as a tool.

Within these two divided camps, groups of Stone Age people were further differentiated by customs and patterns of living. These differences may have been influenced by the climate and geographic features of the country they lived in.

So, however much we may like to reduce the Old Stone Age to a simple pattern, Dr. Burkitt says that the facts have opposite indication. Humanity in the past, like humanity in the present, he declares, was complex.

EMILY C. DAVIS

SCIENCE SERVICE

WHAT IS AN ENGINEER?

To most people an engineer is the man who runs a railroad engine. And a civil engineer is an engineer who politely tips his hat to a lady!

Of a different sort are professional engineers who might be called applied scientists. They are of various varieties, from the civils who build dams, bridges, buildings, roads and other structures, to the chemical kind who engineer the production of new kinds of substances out of raw materials.

The engineer differs from a scientist in that instead of creating new knowledge he applies known technology to the tasks that need to be done in our busy world. The engineer also mixes with his technology a bit of management, finance and organization. In fact, most engineers consider themselves within the ranks of neither capital nor labor, but units in an intermediate managerial class.

Just as engine operators are called engineers, some persons who perform merely technologic functions are also called engineers. The professional engineers feel that there should be a category of technologists for those unconcerned with economic aspects.

This question of names and definitions provides perennial discussion. Latest description of an engineer is by President Karl T. Compton, of the Massachusetts Institute of Technology, in collaboration with a committee of the Engineers' Council for Professional Development:

"An engineer is one who, through application of his knowledge of mathematics, the physical and biological sciences and economics, and with aid, further, from results obtained through observation, experiences, scientific discovery and invention, so utilizes the mate-

rials and directs the forces of nature that they are made to operate to the benefit of society. An engineer differs from the technologist in that he must concern himself with the organizational, economic and managerial aspects as well as the technical aspects of his work."

WATSON DAVIS

SCIENCE SERVICE

NUMBERING AUTOMOBILE LICENSE PLATES

IT is evident that automobile license plates should be so numbered or otherwise marked that they can be most quickly identified and best remembered. With more than a million cars registered in several states, the number of numerals or letters necessary to give each one of them a distinguishing license plate becomes six, and most states require at least five.

The problem at once arises whether license plates containing only numerals or only letters or both numerals and letters are most satisfactory. The variety of license plates now in use indicates that opinions differ greatly. Fortunately the problem of determining the best type of numbering has been investigated by Professor Adelbert Ford and Mr. George F. Derr, of Lehigh University. They tested particularly the readiness and certainty with which preassigned five-symbol license-plate combinations of numbers, numbers and letters or letters alone could be identified among a series of similar license-plate combinations.

It was found that license plates consisting of one letter and four numerals are most easily recognized. Any combination of letters and numerals is superior to numerals alone, and plates consisting only of numerals are superior to those consisting only of letters.

F. R. M.

THE CARE AND PRESERVATION OF DOCUMENTS IN RUSSIA

REPAIRING frail and important documents is proving of importance in Russia. Some one brings in a wad of mouldy papers or a mass of papyrus and says hopefully, "Can you fix it?" and often enough the expert does, by aid of chemicals, lights or electricity.

The Soviet Union has a laboratory for preserving documents, which is doing ingenious work, judging by a report from the Soviet telegraph agency, Tass.

Explorer Peter Kozlov brought from Khara Khoto in Mongolia a great library of 2,000 Chinese scrolls. So mouldy and matted were the thin sheets of Chinese paper that they looked like sticks. To dry them, the laboratory scientists used a special table charged with static electricity of high potential. Gradually, the fragile paper opened.

A bundle of birchbark inscriptions from the Volga German republic was so crumbly that it had to be fixed into thin plates of plastic. Then, by aid of infrared light, the text was revealed. Eighteen sheets of it are in language of the Uigur tribe, dating from the thirteenth century when the Golden Horde overran Europe. These sheets are believed to be the only writing in this language known.

Even tree trunks and branches, inscribed in the little-known Sogdian language, were brought to the laboratory, for first-aid in their preservation.

The future, as well as the past, is the concern of any document laboratory. The Soviet establishment is attacking the problems of space-saving and permanence of records by adopting micro-documents, tiny in size. Instead of microfilm, the most usual form, it plans to use thin layers of platinum containing 20 pages of text, enclosed between layers of special glass. Boxes of smelted diorite or basalt will be made to hold these records. The constitution of the Soviet Union in the numerous languages of its people will be the first document thus prepared.

EMILY C. DAVIS

SCIENCE SERVICE

BOOKS ON SCIENCE FOR LAYMEN

INVENTION AND THE AMERICAN SOCIAL PATTERN[1]

IN order that a book may claim the attention of the alert reader it must have an interesting subject-matter, an engaging style and a point of view. The "March of the Iron Men" has these excellent qualities and more. Not before has there appeared so remarkable an assembly of the significant facts about invention together with a recitation of the individual items invented, all linked to a social philosophy that is thought-provoking in itself and that moreover is vitally put.

The book is composed of what may be called the narrative, accompanied by an interpretation or philosophy. If the reader accepts the philosophy, he will like the narrative, because the elements of causation are well chosen and meaningful. The facts and factors are all well laid hold of—especially the psychological. The purpose of the book is to show how social, political and economic forces grow out of mechanical invention. To put the matter tersely, social invention is the product of mechanical. One may wonder why the same agency has not produced like results elsewhere in the world, but perhaps that is a question for another writer to answer or for Mr. Burlingame to answer in another work.

One of the most delightful things about the book is that, for the casual reader—and most people read a book like this one more or less casually—it may be taken up almost anywhere and left almost anywhere. This is not to say that there is not the most careful concatenation, but rather that the individual links may be examined as units as well as serially or in their relationships. In other words, the book falls into self-significant parts; it also falls into an almost perfectly organized whole.

[1] "March of the Iron Men." By Roger Burlingame. Charles Scribner's Sons, xvi + 500 pp., illustrated. $3.75.

There is, moreover, both realism and romance about the history, if one may be permitted the use of these time-honored, if time-worn, words. It is the kind of presentation that sharpens a mind dulled by too much material of the text-book variety. It may be thought that the book dispels too many illusions to be good for everybody. It rather develops an interesting and probably wholesome skepticism of certain phases of modern industrialism as well as of much that has been accepted as historical fact regarding inventions and inventors.

Now as to the problems not met. We are informed of a collectivism or union (terms not too carefully defined, incidentally) brought about by the development of all the products of invention, but we are given only a faint suggestion of an almost equally imminent disintegration. If the author is to present a complete analysis of forces with potentialities for integration, why not a more careful analysis of the possibilities of disintegration? Why does this discussion end where it does? Is this unity—this collectivism—a lasting thing? The author gives hints here and there that he thinks not, but he nowhere follows up these hints to their logical conclusions. Perhaps the reason is to be found in his desire not to turn his thesis into a preachment, but he has spoken in homiletic vein sufficiently often to make the reader wonder why he has not followed up this side of the analysis. Is the unity of which he speaks inevitable? Will it endure? Of course, the author is under no compulsion to speculate on this particular matter, but the careful reader will wonder why he has not done so.

It has already been said that the book on the whole falls into a well-organized system of events and forces. Again, the critical reader will wonder why a significant chapter in the book should be

labelled "Capital" when indeed the whole book has primarily to do with the formation of capital and its effect upon society. Some of the items in this particular chapter are not vitally significant, and, lacking significance, are quite sure to cause wonder as to why they are thrown in under so significant a caption.

It should be said in conclusion, however, that these criticisms should not dissuade those looking for timely and important information from reading the book. It bears unmistakably the character of the author; it would not be so good a book if it did not. It may be that he is not altogether right, but those who think him wrong will at least be challenged, because where he has thrown himself most forcibly into the book he has presented important evidence. Even if his opinions are disliked, they can not for that reason be disregarded by thoughtful students. This is the first history of invention that is more than a rather thin recounting of facts; it is more than an enumeration—it is a synthesis of mechanical forces with the economic, political and social. It is not just another book; it is a challenging addition to the historical literature of the country.

J. E. THORNTON

BROOKINGS INSTITUTION,
WASHINGTON, D. C.

THE SCIENTIST IN ACTION[2]

THE title of this book suggests a volume intended for popular consumption. However, in spite of the interest of the matters dealt with and the general nature of the discussion, the degree of sophistication demanded by any reader who is to appreciate properly the significance of what is said is such that only real students of science are likely to gain more than a superficial insight into the subject-matter.

The foregoing remarks are not intended to imply any criticism of the work itself, which is admirable in scope and in treatment.

It is impracticable to attempt an adequate review of details. The first four chapters, entitled "The Scientific Outlook," commence by discussing what are called "the four qualities of scientific research." The first, which the author calls *action*, refers to the action of the individual leading to two typical products, the *facts*, which are representative of the second of the four qualities, and the *arrangement of the facts* in the form of theories, etc., which is representative of the third. Finally, we have the quality of newness in which the author distinguishes between the kind of research which blazes a new trail and that which is a mere modification or extension of some already familiar set of principles.

The third chapter discusses description versus the absolute truth, the significance of chance in natural laws; and it criticizes the attitude of mind which feels that certain things should happen because of a belief in the preconceived fundamentality of principles which have been born in the realm of other phenomena. Then the author has something to say in criticism of the assessment of values in various connections in scientific research, the main point being the ambiguity attending such assessment which exists in the absence of a more complete specification of the final aims to be attained.

In subsequent chapters, the question of observation is discussed in its various phases. Scientific observation of events is contrasted with the more frequent observation of all sorts of events by the layman in which there is often great diversity of opinion as to the facts themselves. The tendency of the mind to vision facts in their relationship to one another is emphasized, and discussion is made of the elements which determine the selection of what features of structure shall dominate the pattern. All such considerations are fundamental to

[2] "The Scientist in Action." By William H. George. Emerson Books. $3.00.

an analysis of what is meant by the construction of a theory in the modern sense of the word, and a discussion of present and past theories is made in the light of these considerations.

The last sections of the book are devoted to very practical elements, such as are embodied in questions like: "Is research getting more difficult?" or "Is specialization good or bad?" There are sections on "The provision for the needs of research in the form of research centers," "The cost of research," "The idealistic and routine research," "Facilities and freedom for free-lance research," "Research for humanitarian considerations," etc. Finally, there is a summary which helpfully collects together some of the salient features expressed in the main body of the text.

The whole book is characterized by a broadness of view-point which weighs the merits of the type of thinking done in physics in relation not only to thought in other sciences but also to thought in the everyday things of life. The book can be well recommended to those who desire to meditate upon the significance of their mental processes, and are not frightened by being called philosophers.

W. F. G. Swann,
Director

Bartol Research Foundation

HOW MEN PERISHED IN THE ARCTIC[3]

In comparison with the struggles of explorers in the Arctic and the Antarctic regions against cold and physical hardships and lack of food and sometimes darkness, the famed expeditions of Xenophon and Marco Polo were excursions of a summer's day. Although the Antarctic is more forbidding physically than the Arctic, it was seriously attacked only after explorers had learned how to protect themselves under polar conditions. There were, of course, the tragic journey of Scott from the South Pole and the harrowing adventures of Shackelton, but on the whole the tragedies of polar explorations have occurred in the Arctic.

Soon after the discovery of North America explorers began to seek for a Northwest Passage to the Orient. Since Sir Henry Hudson was abandoned with his son in an open boat in high latitude, almost every generation has had its Arctic heroes and the exciting story of their struggles. In many cases the precise fate of those who have perished has remained a mystery. Now with the accumulation of discoveries of their remains and greatly increased knowledge of the hazards of the Arctic it is possible to complete with a high degree of probability many of these tragic stories. This is what Stefansson has done, and no one is better qualified for such a task because he has spent many years in the Arctic, often for months without sources of food or shelter except such as the country affords, and he not only survived but maintained full health and vigor.

Stefansson writes of the Arctic not only against a background of an enormous amount of experience in it, but he has engaged in a great amount of historical research concerning the five mysteries he has undertaken to solve. They are the disappearance in about 1520 of the Greenland Colony which had existed continuously from about 900 and at one time had about 9,000 inhabitants; the final story of the Sir John Franklin disaster, in point of numbers the greatest Arctic tragedy; the strange fate of Thomas Simpson, a bold seeker for the Northwest Passage; an explanation of the death of Andrée and his companions, who set out in a free balloon, in the summer of 1897, to drift over the Arctic and whose remains were not found until 1930; and, last, the fate of the Soviet

[3] "Unsolved Mysteries of the Arctic." By Vilhjalmur Stefansson. The Macmillan Company. xi + 381 pages and 4 maps. 1939. $3.50.

fliers who disappeared on an attempted flight, in 1937, from Russia to Alaska. This book is recommended for those who enjoy stories of harrowing adventures whose mysteries may be cleared up by historical research and processes of reasoning worthy of Sherlock Holmes.

F. R. M.

PLANT GROWTH-SUBSTANCES[4]

SINCE the discovery, a few years ago, that roots can be induced to grow at will on any part of a plant simply through the application of certain chemicals, there has been, besides a good deal of regular commercial application, almost a craze of experimentation on the part of enthusiastic amateurs.

Several leading chemical companies have put the necessary compounds on the market, but a continuing handicap has been lack of suitable instructions in their use. This is now supplied in a compact book, entitled "Plant Growth-Substances." The first two chapters only are definitely dedicated to the layman. Chapter 1 tells in simple language what the substances are and the principles on which they operate. Chapter 2 tells how to use the commercial growth-substances in quickening the rooting of cuttings.

From there on, the book "goes technical" in the estimation of the author, although any one with a moderately good understanding of the freshman course in chemistry can make pretty smooth sailing of it. In any case, many persons will undoubtedly consider the book worth buying for the first two short chapters alone.

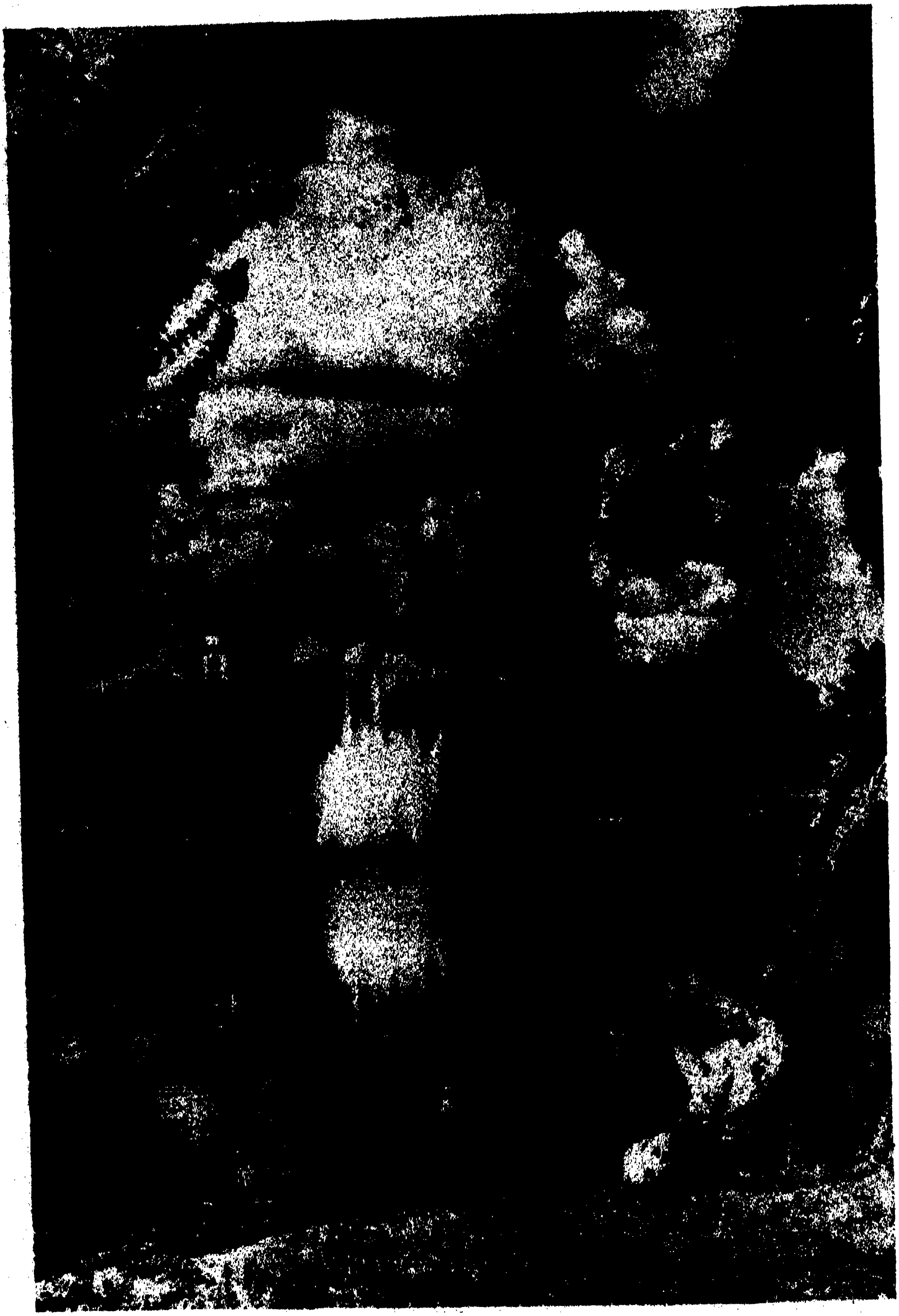
Two growth-stimulating chemicals are recommended by the author. The first, phenyl-acetic acid, is by far the cheaper, but the second, indole-acetic acid, is decidedly the more potent and hence can be used in the most dilute solutions. Proportions ranging from 1 to 100 parts of the acid to 100,000 parts of water are recommended.

Treatment of cuttings to induce roots is simple. Immerse the bottom third of the cuttings in the solution, and remove successive thirds after 12, 24 and 36 to 72 hours, respectively. This will establish the most favorable timing for the particular species under experimentation.

FRANK THONE

SCIENCE SERVICE

[4] "Plant Growth-Substances." By Hugh Nicol. xii + 108 pp. The Chemical Publishing Company. $2.00.



BYRD PARK IN RICHMOND

THE PROGRESS OF SCIENCE

RICHMOND ENTERTAINED THE ASSOCIATION

NEVER in any of its 102 previous meetings was the American Association for the Advancement of Science more adequately provided for and royally entertained than at its meeting in Richmond, Virginia, from December 27 to 31. To the traditional hospitality of the South was added the efficiency of the North. The lighter aspects of life were delightfully interspersed with the austerities of science. An almost continuously sunny sky smiled from above and a soft south wind gave early promise of spring.

It was not a small task to provide for the fifteen sections of the association and the 40 of its affiliated societies which met with it in Richmond. About 200 different sessions were held, before which about 1,700 addresses and papers were presented. All except one of the scientific sessions were held in four days, an average of about 50 sessions per day. It was necessary, therefore, to have over 50 rooms ranging in seating capacity from 50 to 1,200, and the auditorium in the Mosque, in which the general addresses were delivered, had a seating capacity of 2,500. The requirements for presenting scientific papers were so exacting that nearly all these rooms had to be equipped with projection apparatus and provided with means for being darkened. Indeed, it was necessary to show motion pictures in several of them, while nearly 100 microscopes were required for the demonstration programs of the biologists.

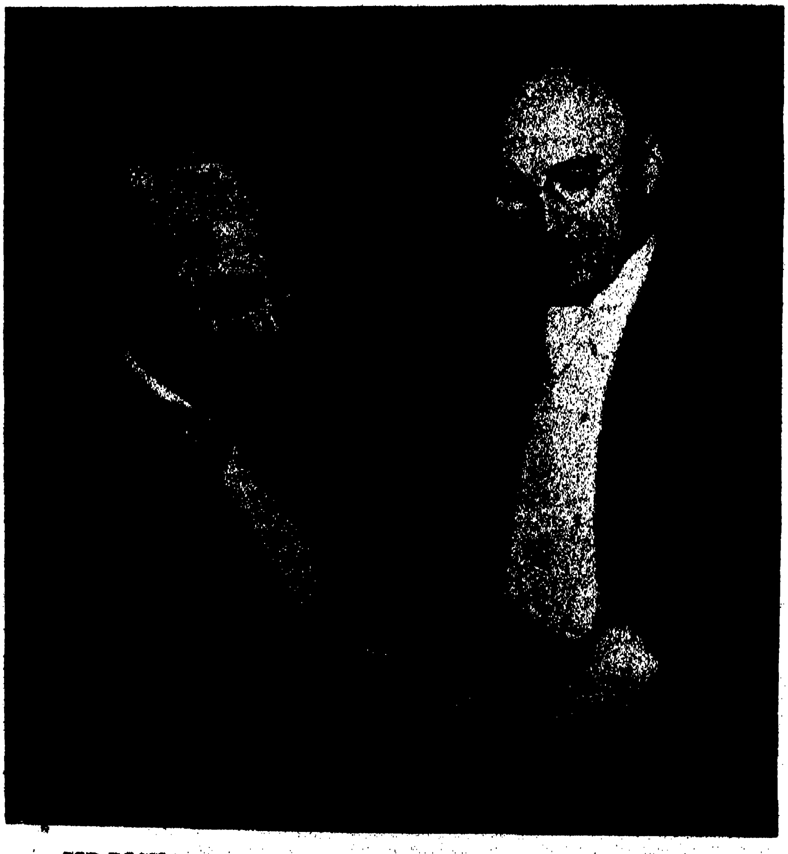
Even the housing of the 5,000 scientists who assembled in Richmond from all over the country presented a problem, for the requirements exceeded the capacity of the hotels. But the hospitable homes of Richmond were opened to its scientific guests, and not a complaint of unsatisfactory accommodations was heard. Before the meeting there were fears that the number of guest rooms for the scientists would be inadequate, but these fears were wholly unfounded, as our fears generally are.

It is impossible to give any comprehensive idea of the contents of 1,700 papers covering nearly the whole field of science. In fact, it would be impossible within reasonable limits even to outline the 240 papers on the program of the American Society of Zoologists or the 148 papers on the program of the Botanical Society of America. It should not be assumed that these two societies were the only ones in the biological fields, for there were nine others, several of which had very large programs. The biologists were by far the largest groups at the meeting which provided unsurpassed opportunities for investigators of living organisms to mingle and interchange ideas. At the same time the meeting often threw them into contact with workers in quite different fields—with chemists now synthesizing with amazing skill the complicated compounds produced by living organisms, with geologists accustomed to looking back along the paleontological record to the time when only simple forms of life existed, with anthropologists slowly lifting the curtain from the origin of man and the evolution of his culture, with psychologists exploring the intricacies of the human mind, with men and women whose interests range through essentially all the inanimate and animate universe about us and to the life and the minds within us. When in any earlier period of the world's history was there such a gathering? Certainly not during the barbaric splendor of ancient Egypt or Babylon, nor even when Aristotle and Plato taught in Greece. Never until the present day was there such variety of interests with such unity of purpose, or such general cooperation and unselfishness. Science has transformed the world

physically and mentally and is setting a model for its social and moral attitudes.

It was not Richmond alone that entertained the association and its affiliated societies. It was all Virginia and the entire Southeast. In physics there is a law that action and reaction are equal. Essentially the same law holds in matters of the mind and spirit. The Southeast put forth great efforts to make the meeting of the association at Richmond a splendid success. And reciprocally, the meeting must have been an inspiration to the Southeast. Its citizens demonstrated to themselves as well as to the remainder of the country what they can do. Every one of its scientists has a new pride in his section of our country. Every one of its universities and colleges will more ardently seek the truth. Every one of its papers will more generously report and support science. Every one of its broadcasting stations will increase the diffusion of science by radio. Every citizen will have a better appreciation of the importance of science and a higher regard for its spirit. Every boy and girl of the Southeast will have a better life because of the meeting of the association in Richmond.

Almost boastingly I make these apparently extravagant but literally true statements, for they express the spirit of science and the purpose of the association.



SIR RICHARD GREGORY AND DR. GEORGE D. BIRKHOFF

SIR RICHARD DELIVERED AN EVENING LECTURE ENTITLED "RELIGION IN SCIENCE," THE SUBSTANCE OF WHICH IS PRINTED AS THE LEADING ARTICLE IN THIS ISSUE OF THE SCIENTIFIC MONTHLY. DR. BIRKHOFF, RETIRING PRESIDENT OF THE ASSOCIATION, DELIVERED HIS ADDRESS ON "INTUITION, REASON AND FAITH IN SCIENCE" THE PRECEDING EVENING.

MR. LLOYD C. BIRD, CHAIRMAN OF THE GENERAL PLANNING COMMITTEE, WITH DRS. MITCHELL AND BIRKHOFF, PRESIDENT AND RETIRING PRESIDENT

The association was organized ninety years ago to advance the interests of science. More truly stated, it was organized to promote civilization, not in the material sense alone or even in the intellectual, but also in those rare qualities of superior human beings that are vaguely called things of the spirit. It is for this reason that the association holds its meetings in various cities throughout the United States and Canada, often at great inconvenience to many of its members. But temporary inconveniences are trivial in comparison with the advantages of having the general population familiar with the achievements of science and inspired by its ideals.

With such purposes the membership of the association is not limited to professional scientists. Its aims are not essentially different from those of all good men and women. Therefore it welcomes the cooperation of all persons, whether they are scientists or not, who have confidence in a better future for humanity and are desirous of aiding in its realization.

F. R. MOULTON,
Permanent Secretary

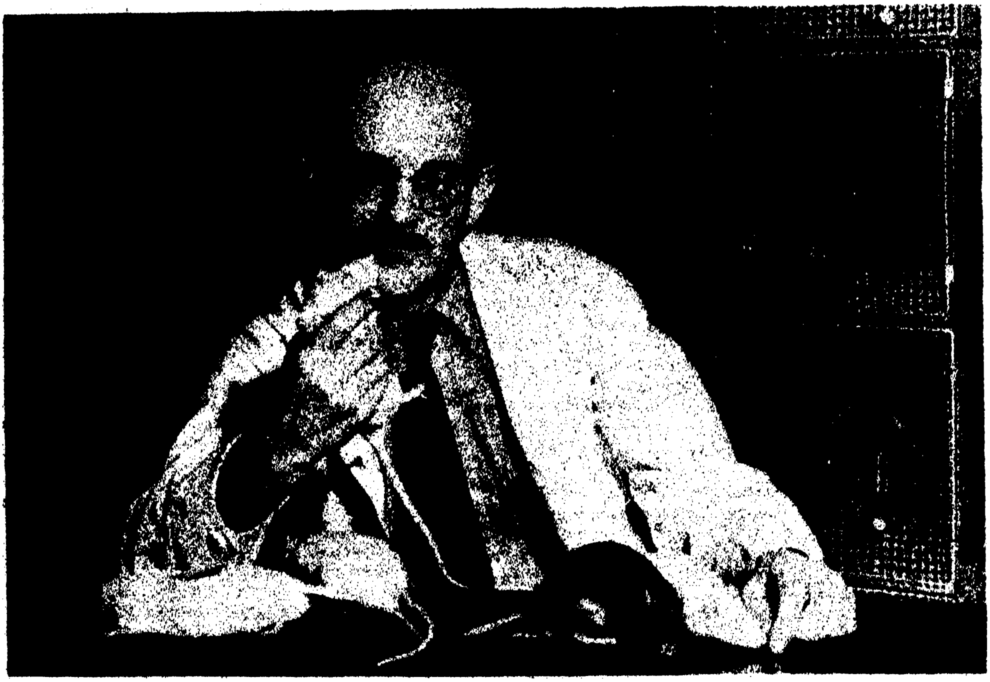
THE THOUSAND DOLLAR PRIZE AWARD

EACH year for sixteen years the American Association for the Advancement of Science, through the generosity of an anonymous friend, has been able to award a thousand dollar prize for an outstanding contribution to science presented at its annual (December) meeting. This year the prize was awarded to Dr. Norman R. F. Maier, assistant professor of psychology in the University of Mich-

igan. The subject of his paper, which was illustrated by motion pictures, was "Experimentally Produced Neurotic Behavior in the Rat."

Animals have long been extensively used for experimentation on problems of nutrition, the effects of vitamin deficiencies, reactions to drugs and injections of microorganisms, the removal or transplantation of organs and on many other problems in biology and medicine. The progress of human physiology and of medicine owes very much to these experiments. Indeed, it is probable that a hundred human lives have been saved for every animal life they have cost. It is only recently, however, that the lower animals have been used extensively for experiments in psychology, the delays being due to overemphasis of what is vaguely called "instinct" and to the egotistical assumption that man is the only animal having reason. It has of course been suspected or known for a considerable period that such higher forms as the primates have the ability to reason, but Dr. Maier's conclusion, reached in his doctor's dissertation in 1928, that rats possess this faculty was regarded by psychologists with much skepticism, an attitude that has been steadily weakened by subsequent researches.

It is clear that investigations of animal psychology are likely to throw much light on human psychology, at least to the extent that animals and men have faculties in common, for animals have relatively simple mental processes, their ancestries and life histories may be determined, in such forms as rats they pass from infancy to maturity in short intervals and they may be controlled to any necessary extent during experiments or destroyed if advisable. The advantages may be greatest in using animals for experiments in abnormal psychology, and this is the field that Dr. Maier has been exploring.



DR. NORMAN R. F. MAIER AND SOME OF HIS EXPERIMENTAL RATS

Certain mental disorders are the most baffling of human diseases and among the

most serious. These neuroses are not produced by diseases, such as syphilis, or by injuries to the brain or by tumors, or by the use of narcotics. They appear without known physical cause. Yet they must have causes, whether they be in inheritances or something in life histories or in environmental factors. If animals are susceptible to similar abnormalities, they open up vast possibilities for controlled experimentation and an eventual understanding of certain types of insanity. Then remedies or preventatives may be hoped for. For these reasons the field which Dr. Maier has entered may become in time one of the highest importance.

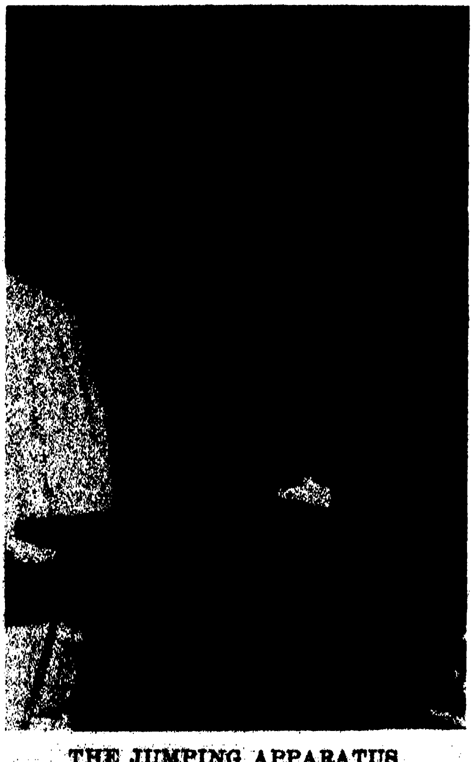
In 1926 Pavlov produced neurotic behavior in dogs, and he has been followed by several other experimenters using generally similar methods. Dr. Maier introduced some new elements in the experiments. He first trained the rats to make a choice of two possibilities, not on the basis of obvious advantages of one over the other but by differences in the patterns on two cardboards to be jumped against. After the preference had been well established and associated with a definite pattern, he interchanged the patterns irregularly. In effect, he took the rats suddenly from an orderly universe into one that was chaotic and in which a choice could not be safely made. Then he introduced means of forcing them to make a choice in a chaos. In contrast with earlier experiments in the field, the restraints and pressures were psychological rather than physical. The consequences were more severe and convulsive in nature, similar to those in human hysteria. It may well be that the animal psychologist and the psychiatrist will work together to the great advantage of society.

The donor of the prize expressed the hope that it might be awarded generally to one of the younger scientists. Dr. Maier is thirty-eight years of age, having been born in the small town of Sebewaing, Michigan, on November 27, 1900.

A NEUROTIC RAT

IN CONVULSIONS AFTER HAVING GONE THROUGH VIOLENT PHASE OF TEARING ABOUT THE ROOM. EVIDENCE OF THE VIOLENT BEHAVIOR CAN, OF COURSE, ONLY BE SHOWN BY MOTION PICTURES.

He took his A.B. degree in the University of Michigan in 1923, majoring in the physical sciences. After teaching in a high school for a year, he returned to



THE JUMPING APPARATUS

A RAT JUMPS THROUGH CARD AND RECEIVES FOOD. A BLAST OF AIR IS USED TO OVERCOME RESISTANCE WHEN CONFLICTS ARISE. THE RAT SHOWN IS NORMAL AND MERELY DEMONSTRATES THE METHOD OF JUMPING.

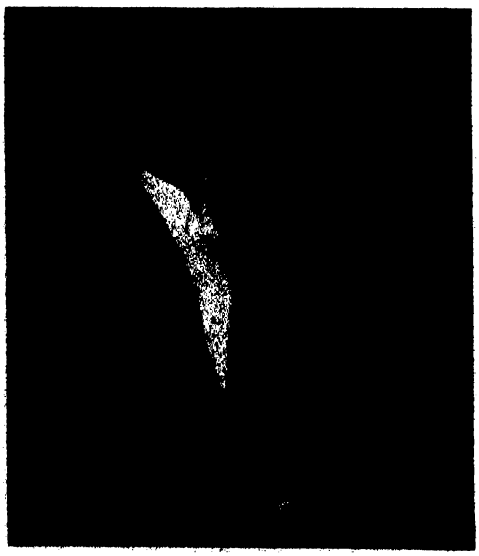
the university and took the A.M. degree in 1925, majoring in philosophy and psychology. He then spent a year in the University of Berlin, which at that time, as the center of the Gestalt Movement, was attracting the attention of psychologists in all parts of the world. He returned to Ann Arbor and took his doctor's degree in 1928. He then received a National Research Council Fellowship during 1929 and 1930 for study with Professor K. S. Lashley at the University of Chicago, after which he became a member of the Department of Psychology of the University of Michigan.

F. R. M.

THE SYMPOSIUM ON MENTAL HEALTH

THE Symposium on Mental Health was an outstanding feature of the annual meeting of the American Association for the Advancement of Science at Richmond, Virginia. Conceived nearly three years ago by the officers of the Section on Medical Sciences as a most desirable project, over fifteen months were spent in planning the details and selecting the speakers. The American Psychiatric Association, the U. S. Public Health Service, the Mental Hospital Survey Committee and the National Committee for Mental Hygiene collaborated in developing the symposium.

The enigmas of mental illness are well recognized by eminent workers to be among the most challenging of all medical problems. Affecting as they do all social strata, they are a pervasive and debilitating influence in our national life, causing much suffering and misery and entailing énormous losses in terms of institutional maintenance, drains on public and private funds, reduced earning power, family disorganization and other financial and human costs. Mental disorders have been and are receiving increasing attention, but many of their aspects are confusing. As an example, one authority states that our bill for mental health amounted in 1937 to merely a billion dollars, which includes both loss of earnings and the cost of institutional and home care. In contrast, an equally qualified worker places the cost at three billion dollars by adding the price paid for unemployability. As to numbers actually afflicted, the former cites a figure of 266,618 institutional cases, whereas the latter by including the emotionally handicapped arrives at a figure of 14,500,000 persons, or more than 10 per cent. of the population of the United States. This lack of statistical and even medical unanimity should be attributed, partly at least, to the fact that our definitions of mental incapacity are legal rather than scientific. In any event, the most hopeful picture of the nation's mental disability is distressing enough. While rapid advances have been made in psychiatry and mental hygiene during the past few years, unfortunately these subjects have been set apart as specialities rather than incorporated in the general practice of medicine, due in no small



PRESIDENT WESLEY C. MITCHELL
AS HE OPENED THE SESSION ON TUESDAY EVENING.

part to the confusing terminology of psychiatry and the impression that it is more difficult than the other branches of the healing art.

The symposium was organized to provide an opportunity for specialists to gather under one roof for discussion and work on a common problem with free interchange of ideas. The development of the program was in many respects unique. Some fifty contributions were prepared and published in advance in a series of six brochures, one for each of the six sessions which were held during three days. These prepublication pamphlets served as a basis for discussion and were not read at the meetings. The first session was devoted to a critical survey of concrete scientific problems in the domains of psychiatry, psychopathology and contributory fields. It was pointed out that, despite the far-reaching advances in the treatment of the mentally ill in the past few years, more patients enter mental hospitals in greater numbers than leave. We are therefore faced with the prospect of a progressive increase in hospitalized mental diseases, necessitating the constant enlargement of institutional facilities, unless more effective means of prevention and treatment of mental diseases can be developed. The chief deterrents to the more vigorous prosecution of research in public mental hospitals at the present time are inadequate staffs, remuneration insufficient to attract the best workers, inferior clinical standards, difficulty in securing appropriate facilities and lack of funds for investigative work.

In the second session attention was focussed on the sources of mental disorder and disease. It was apparent from the evidence submitted that there are sources of mental diseases and disorder in the American community which, by the application of modern techniques, scientific knowledge and social effort, may be ameliorated and uprooted. Certain of these sources are due to innate factors, others are of external origin, involving infections such as syphilis, drugs, food deficiencies and social and cultural mishaps; and they are, to a great extent, modifiable from the standpoint of prevention, treatment and control.

The second day saw the statisticians, economists and social scientists appraising the magnitude and scope of the mental health problem, its financial and human costs, the manifold social problems associated with mental disease and its broad community and social aspects in terms of environmental influences and conditions, their modification and control. The discussion brought out the fact that a primary cause of our relative failure to cope with the situation has been the all too limited and restricted provisions we have made for the care and treatment of those mentally ill. Large sums have been spent for institutional care of the end result of mental disease, on bricks and mortar and other elementary requirements of an urgent physical nature, but not enough on the right type of clinical and treatment facilities and measures to meet the varied medical needs of this class of the sick and in proportion to their numbers. The underlying difficulty has been the failure, in most of the states, to adopt far-visioned comprehensive plans and programs with long-range objectives looking beyond the pressing needs of the moment to the more fundamental requirements of well-conceived and effectively administered therapeutic and preventive measures to deal with the problems of mental illness at their most vital points and at their source. This material led logically to a presentation of the influence of the physical and cultural environment on the direction of human affairs. The solution of this problem requires the collaborative study of psychiatrists, interested in interpersonal relations, and of anthropologists, interested in culture.

The practical aspects of the management and control of mental diseases and disorders were considered on the third

day. It has long been recognized that the care and treatment of the mentally ill and mentally defective in this country is an appropriate function of the state. It is increasingly obvious, however, that in many of the states this function has not been or can not be, under existing conditions, adequately discharged. Unfortunately, sound central state administration is not defended against the evils of adverse political control, interference and exploitation. The obvious remedy is the establishment of carefully constituted, non-partisan boards of control, the enactment of civil service laws and regulations and other protective devices, to the end that professional competence and merit only and not political considerations may govern in determining qualifications for appointment in this work. Particular attention was given to the pressing need for trained workers in the mental-hygiene field and the problem of developing a technical personnel adequate to the need.

The symposium served as a vehicle for the very practical purpose of promoting public interest and support looking to fruitful, nation-wide social action toward the amelioration, prevention and control of mental illness. It gave an authoritative and comprehensive set of principles to guide state and local governments and administrators in developing sound progressive and more nearly uniform policies and measures for the care and treatment of the mentally ill and defective. Inasmuch as mental illness is a national problem, the issues call for a union of scientific and social effort in a concerted, coordinated and more effective attack on mental disorders and disease than heretofore. Hence the need for an alliance of the medical, scientific, educational and social forces of the country that can contribute, in one way or another, to the solution of this problem became emphatically evident.

MALCOLM H. SOULE,
Secretary for the Medical Sciences

CONSERVATION TEACHING—A PANEL DISCUSSION

RADIO effectively teaches science in the grades. It combines an element of novelty with reliable instruction; it is a help to the teacher who is inadequately trained in science, and it can impart scientific methods of investigating and thinking more effectively than text-books can.

This is the gist of a paper presented before the American Nature Study Society on December 29, 1938, by Dr. F. R. Moulton, permanent secretary of the American Association for the Advancement of Science. Miss Mary E. Leeper, of the Association for Childhood Education, stressed the values of science education for children of all ages. Science stimulates healthful play, artistic activity, keen observation and clear thinking —by kindergarten students as well as scientists. It also provides a medium for creative recreation in which whole families may participate, and such participation is vital to our social well-being. Science education therefore must be undertaken and planned for its social as well as its cultural values.

The American Nature Study Society will sponsor local clubs which will use radio programs and printed materials of the American Association for the Advancement of Science. Its past president, Dr. Edith M. Patch, already has taken part in one of the association's school broadcasts and has helped plan broadcasts for 1939. In addition to being a well-known entomologist, Dr. Patch also is senior author of one of the leading series of science readers and of several nature books for children.

Compulsory courses in conservation are likely to do more harm than good.

This was the opinion of several speakers in the panel discussion on conservation held by the American Nature Study

Society during its meeting in Richmond on December 28, 1938. These speakers cited their own experiences with schools in which state laws force the teaching of conservation for at least one year. In most cases, the courses which meet these laws are poorly planned, are squeezed into already crowded schedules, and are taught by unprepared teachers. Such courses make a bad impression upon students, and that bad impression is likely to continue into their adult lives.

Equally bad is the system by which visiting speakers from sportsmen's organizations lecture to grade school children on conservation. Most of these speakers are hunters, not conservationists; they are interested in destroying rather than saving; they lack thorough understanding of the many phases of conservation and the extent to which these phases interlock. The need for such understanding, with a conservation program which starts with the ground and extends to man, was stressed by Dr. Paul Sears, author of "Deserts on the March."

Conservation education which takes exhibits and demonstrations into the village and country schools was described by John C. Caldwell, of Tennessee. Mr. Caldwell has a car, a trailer and a tent; he can hold a meeting in a town or stop to work with children by the roadside. Tennessee's trailer educational service has visited 350 schools and held 600 meetings. Each visit is intended to begin a conservation project in which teachers and children cooperate. Once such a project is begun, there is no need for a law to force the teaching of conservation.

Carroll Lane Fenton

DR. FRANK PIERREPONT GRAVES
WHO DELIVERED THE FOURTH ANNUAL LECTURE SPONSORED BY UNITED CHAPTERS OF PHI BETA KAPPA. THE SUBJECT OF HIS ADDRESS WAS "IS EDUCATION A SCIENCE?"

BROADCASTS FROM THE ASSOCIATION MEETING

A total of 34 broadcasts, several over national networks, were delivered by scientists attending the meeting of the association at Richmond. The subjects ranged from theories of the origin of the earth to how we taste, from a discussion of conditions in Greenland to game hunting in Fiji. The after-dinner speeches of the press dinner were carried by a local station for two and one half hours.

The broadcast of Sir Richard Gregory on "Religion in Science" stimulated the largest number of listeners to write expressions of approval and for copies of the address. Perhaps this is an indication of a longing for some substantial

new basis for religious beliefs, or perhaps it is an evidence of the vague fears of impending disaster that now pervade the world. In any case, it carries the lesson that scientists should no longer think of science as something apart from the general currents of life but as an influence that pervades every phase of our existence.

It is a difficult task to arrange for 34 broadcasts in four days by men in a strange city who are not generally accustomed to the exactions in time of the radio. Not only must all broadcasts begin on appointed times within a very few seconds, but they must be almost exactly of prescribed lengths. There are problems of delivery before the microphone, which is no more inspiring than a one-way conversation over a telephone. Yet the arrangements for the broadcasts were most efficiently taken care of by Professor G. W. Jeffers, of State Teachers College, Virginia, and the broadcasts themselves were of a high order of excellence. The association and the public owe much to Professor Jeffers and to the broadcasting stations for making available by radio so many interesting scientific discussions.

From the point of view of specialists such broadcasts of science as those delivered at Richmond may not seem to be important. But it should be remembered that they reach the masses on whom the higher levels of society ultimately rest. Consequently, it may be that these influences, many times repeated, will eventually have most important effects. Is it not true that the civilizations that have failed all went down because of the degradation and disintegration of their masses?

F. R. M.

THE PRESS AT THE VIRGINIA MEETING

THE annual winter meeting of the American Association for the Advancement of Science at Richmond was probably the most thoroughly "covered" scientific gathering in history.

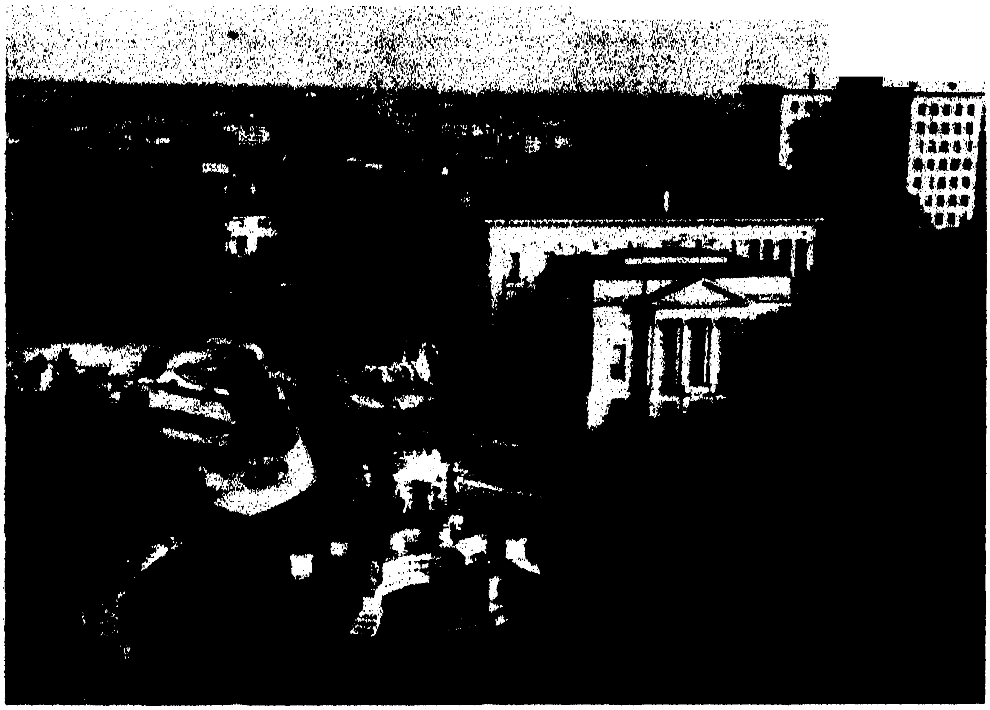
From the press room in the John Marshall Hotel well over a half million words were distributed by wire and by mail. Columns were printed daily by newspapers from coast to coast. Besides the four press associations represented—the Associated Press, the United Press, the International News Service and Science Service—twenty-one daily papers had special correspondents in Richmond to report this meeting.

The meeting was by all odds the "big news" of the week—notably free of crime, international complications or political scandals. Although no major story "broke" at Richmond, such as the first announcement of a scientific discovery of universal significance, yet the news value of the papers presented remained throughout on a high level. There was very little of the stale or trivial.

The exceptional coverage may be attributed to various reasons. First, the facilities offered the correspondents were such as have never been equaled at such a gathering. The work of Dr. Sidney S. Negus and his colleagues in charge of press arrangements for the Richmond committee may well serve as an example for such local committees to strive to equal for many years to come.

Secondly, it is hardly possible to express too warmly the appreciation of the press writers for the great abundance of material provided in advance of the meeting and for the efficiency with which the office of the permanent secretary made it available to the science writers.

Thirdly, probably more than ever before, the reporters were challenged to do their best by the extraordinary hospitality of Richmond and of the Virginia committee. The major event preceding the opening of the convention itself was



VIRGINIA STATE CAPITOL AT RICHMOND
SHOWING THE GOVERNOR'S MANSION IN THE DISTANCE AND THE EQUESTRIAN STATUE OF GEORGE WASHINGTON IN THE FOREGROUND.

a dinner for the press, arranged by Dr. Negus and his associates, attended by more than 200 Virginia editors, at which the members of the National Association of Science Writers were honored guests. Throughout the week lunches, typewriters, messenger service and a special recreation lounge were provided for the newspapermen. Dinners were arranged for them at the homes of prominent Richmond families. The visiting press felt that it owed for all this more than it could hope to pay but that some compensation might be given by the fullest and most accurate reports possible. Every reporter was spurred to do his very best work. The press room was a busy place practically 24 hours a day.

The reporters hope they did a good job —and this is most particularly true of those of us who happen to be members of the National Association of Science Writers, for we feel that we have played some small part in an extraordinary development which reached its culmination, to date, at Richmond. This is the rapid development of friendship, mutual appreciation and mutual confidence between the scientist and the newspaper man, which has taken the place of suspicion on the one hand and irresponsibility on the other.

There were no broken confidences nor, we hope, seriously inaccurate or distorted reports. The attainment of this happy result has been the culmination of a labor of years. A noteworthy contributor to this achievement has been Austin H. Clark, for many years the press director of the American Association for the Advancement of Science, and the tokens of warm regard presented to him at the press dinner on Monday night were inadequate expressions of our gratitude.

Members of the National Association of Science Writers who covered the summer meetings of the association at Ottawa last June were warm in their praise of the hitherto unequaled press arrangements in charge of Ernest Rhodes, of the Dominion Department of Agriculture. Ottawa eclipsed anything that had gone before; Richmond surpassed Ottawa.

THOMAS R. HENRY,
President, National Association of Science Writers

MOTION PICTURES AT THE RICHMOND MEETING

EACH year motion pictures play an increasingly important rôle in the meetings of the American Association for the Advancement of Science. This year some twenty of the papers presented in the special sessions used motion pictures as a method to demonstrate, in part or in entirety, the results of research. About one third of them were photomicrograph films in the field of the biological sciences.

An added feature of the Science Exhibition was the more or less continuous showing over a period of two and one half days of a wide variety of technical and popular scientific films. Many of the research films shown in the special sessions were repeated before this more general group. The United States Film Service made a substantial contribution by providing a series of government films. "Three Counties against Syphilis" was noteworthy. "The Plow that Broke the Plains" and "The River" were repeated two or three times, upon request, for the audience was a continuously changing one.

Color and sound films were liked best. The bird pictures contributed by Dr. Gross and Dr. Pirnie and the insect pictures of Dr. Melander and Mrs. Brues were at times breath-taking in their beauty.

In general the film exhibition was well attended; the hall, seating 175 people, averaged a little less than half full. The attendance during the first part of the morning was low; on the other hand, at a popular picture in the late afternoon every seat would be occupied, with people crowding around the door for a view of the screen.

In general, the addition of the motion pictures to the Science Exhibition proved popular.. It might have been anticipated that visitors would be distracted by them and spend less time than they otherwise would have done in the exhibition hall proper, but the consensus of opinion seems to be that, as a whole, the showing of the motion pictures increased rather than decreased the attention received by the exhibits.

The latter opinion received some confirmation when a group of biological motion pictures by Chambers, Bailey and Strandskov were shown at four o'clock on Thursday afternoon. Notice of this special showing was posted in the morning at the Medical College, the meeting headquarters of the zoologists, and a number of biologists went down to the Mosque especially to see them.

The motion pictures of native and animal life in Sumatra shown by Dr. Wm. M. Mann, of the National Zoological Park, attracted by far the largest audience of any film. These pictures, shown through the courtesy of the National Geographic Society, were exhibited on Saturday morning in the auditorium of the Mosque in order to accommodate the great number who came to view them.

W. C.

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THE SCIENTIFIC MONTHLY

MARCH, 1939

RESEARCH IN INDUSTRY

By Dr. FRANK B. JEWETT

PRESIDENT OF THE BELL TELEPHONE LABORATORIES

ALL the fundamentals of industrial research—whether of research itself, its management, the relations of it to the other activities of the business of which it is a part, or to the success of that business—are in fact few. When it comes to the recital of the specific achievements of research the case is different. In this field one can expound *ad lib* since there is always fresh material in the silk hat.

In a sense research in the world of physical things, even as we define it today, is as ancient as man himself. Every curious man who sought by trial to know why or how something behaved as it did was a research worker. If he was satisfied with the knowledge he derived from his experiment or if he merely imparted it to others of the clan, he was an embryonic fundamental scientist. If, however, he sought to employ his new knowledge to the making of a better tool or weapon, and more particularly if he was impelled to make his trial because he might thereby achieve that end, he was an ancient progenitor of all present-day industrial research men.

Strictly speaking, however, research in the physical world and more particularly industrial research are very young in terms of human experience. As major factors in influencing social thinking or acting they are scarcely more than a century and a half old. Industrial research, which is the offspring of fundamental research and collective effort through organization in industry, has been a force in the world for little more than fifty years. Conscious training of men for it is younger still, having developed well within my lifetime. Few, if any, of us older industrial research men were ever aiming for a life in industry when we sought training in basic science.

Because of its youth and the number and variety of this new child's characteristics, it is small wonder that society is bewildered and occasionally alarmed and resentful. While business has made a good deal of progress in the direction of abandoning its earlier attempts to ignore the child or force him to conform to ancient tribal customs, society generally and politics especially still persist in a determination not really to understand him; this despite the fact that they have gone far enough to like the new things he brings home. At times they go so far as to appropriate his language, even though their knowledge of what the words mean is a bit hazy.

The principal thing which distinguishes the world of the past one hundred fifty years from the ages of human history which preceded has been the wide-spread acceptance of the so-called scientific method as the best, most powerful and most expeditious means of exploring the unknown, and the results that have followed that acceptance. Fundamentally it is nothing but an idea —the concept that the surest way to test

a hypothesis is to subject it to a succession of simple controlled experiments, each of which can be repeated at will, and to be guided rigorously by the results. To be successful its votaries must observe strict intellectual honesty. Recent history shows that in this concept man has hit upon one of the most, if not the most, powerful tools for change ever created.

The scientific method and the techniques which have been evolved under it are infinitely more powerful than any methods of abstract reasoning or dialectics. Applicable theoretically in any sector of inquiry, the scientific method is obviously easier of full application in the realm of the inanimate physical world than in those which involve animate things. This is not so much because the problems here are less complex than elsewhere. Rather it is because of the greater ease of conducting really controlled experiments.

One thing that the successful research man learns early in his career is the application to physical science, whether fundamental or applied, of the old axiom of mathematics that there must be as many independent equations as there are unknowns if he is to evaluate the unknowns. Another thing he learns early is that failure of a controlled experiment to work out as expected is not really failure but actually a step forward. It enables him to modify his preconceived ideas and organize another experiment. One of the commonest and frequently one of the most tragic errors of society is to draw definite conclusions from experiments where many factors are not under control. In such an experiment it is a matter of pure chance if proper conclusions happen to be drawn. Even then the presence of other factors than the one claimed to be dominant is an invitation to unending wrangling. I am sorry to say that many so-called engineering experiments are of this character. That is why we so frequently use such large "factors of safety"—really factors of ignorance in applying our results.

Viewed in retrospect, the development of industrial research during the past forty years appears as logical and inevitable as the development of science itself. When at the beginning of the century the first timid adventures were being made by a few industries with a handful of young men lured from the ranks of teaching, the scientific method was already firmly established in the domains of physics and chemistry. Brilliant results in the form of new knowledge had already been obtained, and some of it had been put to work by clever inventors and engineers. Only the young and venturesome were attracted to the new field, since the traditions of the university then were strongly against anything which tended to sully the quest of knowledge for its own sake. Although he relented somewhat with time, I think I never quite regained the respect of my old chief, Professor Michelson, after I forsook the halls of learning for the walls of industry.

Many of the newer industries which had grown up in the 80's and 90's were the first to sense the need of something more than was provided by men of ingenuity, inventors and engineers. Principally, they were in the fields of applied electricity and modern chemistry. In them the control of tradition and art was weakest or substantially non-existent. Further, all the personnel was relatively young and inclined to be daring—social security as the inalienable right of all had not yet been heard of.

In a few of these industries progress had been such that problems beyond the ability of inventors and engineers to cope with had arisen. In others it was felt that if only some known fragments of new knowledge could be pieced together and applied, much greater progress

could be made. A few wise men saw that in both circumstances hope lay in introducing into industry the rigorous methods of fundamental science and men trained in their operation.

The innovation worked—in some cases far beyond original expectations. It grew upon what it fed, and as one astounding achievement after another came to be known and publicized the virus spread. Gradually but with increasing acceleration more and more industries based on science came to incorporate more or less of industrial research into their organic structure. Mainly at first the expansion was to industries in the fields where the trial started, *viz.*, those of physics and chemistry and to those of more recent origin. Industries which were ancient arts before modern science was born were the last to make the plunge despite the fact that in many cases they were most important to society and had most to gain from the new method.

As time went on and the results of the scientific method began to pile up hills and mountains of new knowledge in the domains of biology and botany, the intrusion of industrial research organizations took place in industries in these fields. The whole evolutionary process in industry put pressure on the institutions of learning from which alone could come the army of trained men and, to a large extent, the streams of new knowledge needed to supply power to their mills. The pressure was from two directions—from industry's demand, on the one hand, for more and better men than could be supplied by kidnapping from the ranks of the fundamental science scholars, and on the other from youths who, with no desire to become academic scholars, were nevertheless avid for exactly that training as a basis for life in the new realm of business and industry.

We all know that the response of university and technical school alike was wholehearted and efficient. While there are, I suppose, still some in academic circles who profess to see something akin to prostitution of scientific research in the thought of employing it for anything save the acquisition of knowledge for its own sake, their number must be small. Certainly in recent years the great majority of men in training have had their eye on a life in industry.

The World War gave a great impetus to meticulous industrial research and the decade of the 1920's witnessed a veritable stampede of industries, large and small, to climb on the band wagon. These ventures ranged all the way from well-considered undertakings, which have lived and prospered, to foolish things undertaken in all sincerity but with complete ignorance of what was required either by way of personnel or coordination. Most of these last have quietly folded up and disappeared. So too have many of those which with no ethical justification were created in name only for the purpose of cashing in on the popular esteem in which industrial research had come to be held.

Looking back over the history of industrial research to judge its relation to business success, one thing stands out in every case with which I am familiar, namely, the hard internal sledding of the initial years. Barring possibly some of the newest industries which have sprung directly from the research laboratory, that is, where *it* was the parent rather than the child, the first years of every real research organization have been soul-trying years. This was so even in the early cases already mentioned, where there was as yet little or no tradition or art. Even here the existing organization was one of "practical" men and per contra the intruders (for such they were looked upon) were "impractical" theorists. I suppose it is bound always to be so.

The first big job was to sell the new

idea and to acquire that confidence and respect without which nothing could be accomplished. Those who tackled too much at the start were properly and rightly hazed. The wise ones took their time and started by picking out problems which were easy from their standpoint but which had the "practical" men half crazy with insomnia.

In the early days nothing was known of just how best to relate the research activity to the other parts of the business organization, and every conceivable arrangement was tried. Frequently it was made a part of the existing engineering department. Sometimes it was set up as a thing apart from all else as a sort of free lance consulting affair tied into the main organization through some superannuated vice-president to whom it seemed desirable to assign more work. All kinds of arrangements are still to be found, but in the main they are no longer haphazard but have some justification in reasons peculiar to the particular industry of which they are a part.

In some of the larger industries which have had long experience with research, where the function has attained large proportions and where the corporate set-up involves a number of more or less autonomous companies, as is the case with the Bell System, General Motors and a number of others, the research laboratory is now set up as a legal corporation. The presidents of these research corporations are part of the general directing management and so bring to it first-hand information.

In other industries, where for one reason or another the corporate form of organization has not been adopted, despite the size and importance of the research function, the research director is nevertheless a part of the administrative management, either under that title or the title of vice-president and research director.

Either of the arrangements just mentioned has the advantage over others in that the responsible head of the research organization participates directly in the consideration of matters affecting company policy. In some industries many important policy decisions are vitally affected by exact information on the present and prospective state of the art as viewed through the eyes of the research department.

Any form of organization which interposes one or more links between the research director and the top management inevitably tends to dilute or distort this information. Conversely, the research organization tends to be deprived of valuable information connected with company affairs which may have a distinct bearing on the trend of current work.

The men who are now research directors, under whatever title, were originally research workers and creative producers. This is particularly true in the larger research organizations where the demands of administration, broad decision and a thousand and one things which consume time leave little opportunity for individual participation in creative work. To any one interested in appraising the value of research in industry this fact is one of some importance, since it tends to refute a very common misconception. This misconception is that the activities of the research department are determined by the director and carried out by his associates. In a very general sense this may be true in so far as the views of the director operate to determine broad fields of inquiry. Beyond this he frequently has little concern with or influence on the details of research investigation, and his most active participation in the day-by-day creative work is likely to be that of a critical appraiser who brings to bear upon results obtained the benefit of broad knowledge and long experience.

One of our most distinguished research directors once said, somewhat facetiously but with a good deal of truth,

that if one wanted the best possible appraisal of the prospective value of a new research development he would consult the man who had done the work. Next in line would be the supervisor of a group of related research activities and finally the director of the laboratory, but never a vice-president unless perchance that vice-president happened to be the research director just mentioned.

What I have just said does not mean that industrial research laboratories should be left to function in their own sweet way, nor that the general administrative management has not a very great concern in them. Management must from time to time decide how much money can properly be allocated to the conduct of research and in what general directions that research should be pursued. The research director as a part of management is responsible for setting still more accurate sailing directions. What I am attempting to say is that the farther one gets away from the actual doing of research, which is an individual creative act, the less likely is it that the detailed direction of work will be wise and the more likely that it will be influenced by factors of immediate expediency. This is, I think, particularly the case with investigations on the frontier of the field involved—investigations which if successful are likely to be many times more valuable than those concerned with nearby advances in the art.

Before leaving the matter of the general set-up and operation of the industrial research laboratory there is one further conclusion which it is generally agreed has resulted from past experience. This is that of all the integral parts of industry the research department is the one which can probably be least safely tampered with in times of violent business fluctuation. I say this not because research men are entitled to more consideration than others, but simply because the productiveness of an industrial research organization is drastically affected by anythng approaching violent fluctuation in personnel or policy. The most important problems with which the research organization is concerned are complicated affairs which require the cooperative action of a considerable number of scientists long trained in the field of their special interest and accustomed to working together. A too sudden growth or a too sudden curtailment of the research force affects its productivity out of all proportion to the change in numerical numbers—this irrespective of the inherent caliber of the individuals added or subtracted.

As a matter of fact experience in many fields has shown more frequently than not that the most valuable contributions of industrial research are made at times of depressed business activity. The reason for this I will touch on in a moment.

Summed up, what I have just said might be stated somewhat as follows. If business wishes to obtain maximum value from its research organization and for the money it expends on it, it must be prepared to guard these expenditures against a too direct influence of current business variations. It must be prepared to expand or contract research activity as far as possible in conformity with more fundamental factors, otherwise it will lose much money in unproductive effort.

The current activities of every industrial research organization are always of two kinds, although the relation in the amount of the two may vary widely from time to time. On the one hand, is the work of a fundamental character on problems which, if successfully solved, will be of advantage to the industry at some more or less distant future time. This work having little or no relation to the current operations of the industry, is usually of paramount value. Every research director struggles mightily to maintain this type of work at a maximum.

On the other hand is work concerned with the problems of current operation. This type of work arises either because the research laboratory is set up to do it or because problems arise in current operation which are beyond the capacity of the operating people, including works laboratories, to cope with. The research organization is then appealed to for assistance and simply can not resist extending help, even though at the expense of more valuable long-range investigations. The number and urgency of such problems are of course greatest in times of intense business activity, and in consequence the amount and to some extent the efficiency of work on fundamental problems are least at these times.

Fortunately it is relatively easy for trained research men to shift from work in one category to that in the other. The mental processes, the techniques and the skills required are essentially the same; hence the statement made a moment ago, that in many cases the most valuable fundamental work is accomplished in times of low business activity, for it is then that the research organization is least bedeviled by urgent demands for assistance in the operating departments and has maximum man-power to apply.

Coming to consider more specifically the relationship suggested in the title, even a cursory review of modern industry can not help but disclose a close relationship between extensive efficient industrial research and success in the business to which it is attached. Among industries based on applied science we find those to be most successful in which the research function is large, relatively old and where its place in the business structure makes it an integral part of executive management. No better proof could be wanted that many successful industries have come to realize the importance of research to continued successful operation and maintenance of prestige.

If we examine further the internal composition of these industries we find increasing evidence of an indirect influence of the research organization in the number of men who, starting in the research laboratory, have been transferred to the operating departments. This transfer is most noticeable in the case of radically new developments which have grown out of research attack. Where such new things are to be put in commercial production or operation it is almost inevitable that this transfer should take place.

This phenomenon suggests an indirect influence of research on business success which I sometimes think is equal to if not greater than many of the direct benefits. As one looks back over the changes which have taken place in business operations during the past two or three decades, he can not, I think, escape the conclusion that more and more of the non-technical problems are being approached from the scientific point of view and so far as is feasible under controls of the scientific method. In part this is doubtless the result merely of emulation of the methods employed so successfully in physical research. In part the tendency is doubtless the result of the infiltration of men from the research laboratory who have carried their special methods of thought into new fields.

The most obvious contribution of the research organization to success in business is the thing for which it ostensibly exists, namely, the creation of new things. But no research organization, however extensive or competent, can hope to guarantee to its industry production of all new ideas. When such ideas, and particularly those of a radical nature, arise outside the industry and are presented to it for consideration, it is more frequently than not the knowledge possessed by the research department which enables management to determine its proper course. This is particularly true when patents are presented, for then

management is limited in its courses of action. It must either decide to acquire rights; to develop alternative ways of accomplishing a similar end; or to discard all thought of usage. Ofttimes the research department can give almost immediate advice. At other times it can at once perform the necessary examination needed to produce the answer. Likewise, and this more frequently than not, it will be found that in the existing work of the laboratory—work which is itself protected by patents—there exists the currency with which to purchase freedom of use if such purchase is indicated as necessary—a purchase which might not be possible with money alone.

Every business undertaking is fraught with more or less risk. This is true both as to the overall operations and to the operation of the various departments as well. Long observation has convinced me that of all its new operations those based on the results of research are by far the least hazardous with which business has to cope. In saying this I refer to the hazards of technological error and not to the hazards of error in commercial judgment which cause business to embark on an otherwise sound venture at the wrong time or in the wrong place. The reason for this feeling is based not on any idea of superior intelligence among research men but upon the fact that scientific research tends to eliminate error. Each error as it is found is corrected, with the result that the chance of gross error at the end is almost non-existent. I can not recall a single major failure of a project based upon adequate research. The few I remember which were attributed to the research organization were found on examination to be due to failure of the manufacturing or operating departments to observe *exactly* the controls specified. There is always an urge to do just this in order to save time or cost.

One essential and last step in the research method is the "trial installation" trial of the new things under rigid observational control of the laboratory under actual service conditions and on a scale sufficiently large to be a fair operating test. Many things inherent in large-scale operations can not be duplicated in the laboratory nor can man's infinite capacity for finding ingenious ways to cause trouble always be forecast. Sometimes nothing untoward develops, but sometimes costly errors are guarded against.

No trial installation is ever undertaken until all reasonable work has been completed in the laboratory, since it is an axiom of industrial research "That what *can* be done in a test-tube *may* be done on a large scale, but what can not be done in the test-tube can not be done commercially."

The money and time consumed in trial installations makes them frequently the most trying thing with which the research director has to deal, particularly when the new thing is most attractive and has given little trouble in the laboratory. Management then is like a boy in the presence of green apples—it yearns to pick the fruit before it is ripe.

Now finally a word about the future as I see it. As a result of forty years' experience research is firmly intrenched in the structure of many successful industrial undertakings. With them it is proven as a principal—in many cases *the* principal—insurance to continued success. Have we already exhausted most of its possibilities? The answer seems clearly "No."

In the first place there can be no question as to the power of the method to produce positive results. Likewise there are still considerable sectors of business where research is as yet embryonic or non-existent, but in which the conditions are identical with those where it has proven successful. This is especially the case in small industries and in those of ancient origin. In the one the problem

is that of selecting some form of cooperative undertaking among concerns similarly placed or of developing more institutions like the Mellon Institute. In the other it is the problem of breaking down age-old inhibitions.

More persuasive still is the picture of what is going on in all the domain of fundamental science where the research method is universally applied. The stream of new and potentially useful information which is flowing into our world of knowledge is stupendous and there is no end in sight. If it is to be used successfully by industry it can only be by a continued application of research in business. Man is and doubtless will remain an inquisitive and acquisitive animal.

What we will do with the new and cheaper things we create or how we will regulate and control that use is another question, speculation on which is outside the scope of this talk. But I would venture the suggestion that to solve the great underlying problems which will confront society in the years ahead we will require investigations undertaken on a far vaster scale and—having in mind our political theorizing—in more orderly fashion than we are now accustomed to. We need not here speculate as to the best auspices under which to make the attack—whether by enormous private undertakings or by action of the state or by a combination of the two. These underlying problems arise largely from what we humans have done in a material way these past 150 years. Broadly speaking, we have been prodigal in a free use of nature's stores without more than a speculative concern about what we would do when the stores were depleted. I doubt if we could have done otherwise. To cite but a few examples—we have exhausted soil fertility, which nature unaided can not restore; we have destroyed forests and have consumed minerals which nature will not replace. Our whole present civilization is primarily grounded in the use of natural products. Each step forward that we have made has increased our demand for mechanical power and accelerated our drain on the natural supplies which were accumulated through long geologic ages.

On the other hand, in our progress we have learned how to make many blades of better grass grow where one poor one grew originally; we have learned how to expedite the restorative processes of nature; how to make and employ substitutes and how to create usable power in ways nature never employed. And although much of our knowledge is in the laboratory test-tube stage, we do see a way out and can extricate ourselves and go forward if we have the wisdom and will to follow the charted course which scientific research indicates. There is no reason to believe that the problems of waste land from forest operations; of depleted fertility; of crops for other than food purposes; of low-grade ores, or of substitutes for metals and materials now showing signs of exhaustion, can not be solved; and fuel in abundance also—first probably through utilization of the billions of tons of lignite and low-grade bituminous coal, and later possibly from conversion through chemistry of the sun's energy stored up annually in growing things.

As I look at the problems ahead from the background of the past, it seems to me that so far we have made a great many trial installations in preparation for the bigger job ahead.

MENTAL DISEASE—A CHALLENGE

By Dr. WINFRED OVERHOLSER
SUPERINTENDENT, SAINT ELIZABETHS HOSPITAL, WASHINGTON, D. C.; PROFESSOR OF PSYCHIATRY, GEORGE WASHINGTON UNIVERSITY SCHOOL OF MEDICINE

MENTAL disorder is a subject which merits the attention of every intelligent citizen, for it constitutes to-day one of the largest and most pressing social problems. It is important from the medical, public health, social and economic points of view. Very nearly one half of the hospital beds of the entire country are devoted to the care of mental disease. At the beginning of the year 1936 there were, in the United States, 469,100 patients in mental hospitals or on visit to hospitals, and during the year following that date 150,208 others were admitted. Thus, during that year (1936) well over 600,000 people were at some time or other patients in a mental hospital—in other words, one out of about every 150 adults of the general population!

The investment in mental hospitals in this country is approximately one half billion dollars, and the annual cost of the maintenance of these institutions is about one hundred million. The wreckage of human lives, with the accompanying loss in productivity to the community, and the untold heartaches caused to the families of mental patients, can not be fully estimated or expressed in monetary terms. One need only mention, too, the bearing of mental disorder upon dependency and delinquency. There certainly are relationships here which are difficult to evaluate but which are none the less real. To bring the matter somewhat more closely home to the reader, it may be pointed out that it has been estimated from the statistics of the New York mental hospitals that the probabilities are that of all persons in New York, at least, fifteen years of age or over, one out of every twenty will at some time during his life be a patient in a mental hospital.[1]

In spite of the vital importance of the topic of mental disorder, there is probably no subject on which more misconceptions of facts are prevalent among the public and even among many educated people. When it is borne in mind that for countless centuries, from the time of Christ or earlier down through the Middle Ages, mental derangement was interpreted as due to demoniac possession, presumably as a punishment for sin, it is perhaps not strange that relics of the medieval attitude still hold over in the form of a disguised fear or hatred or contempt of the mental patient. Many persons even to-day are inclined to look upon the existence of mental disorder in a relative as a "stigma," as something to be kept secret, even though intellectually they may recognize that it is simply another manifestation of disease, and no more cause for shame than the occurrence of, let us say, pneumonia. The lot of the mentally ill person has never been a happy one, but for too long a time in man's history and, indeed, even to-day in some parts of the United States, that lot has been and still is being made more unhappy by man's inhumanity to man.

Institutions for the care of the mentally ill are relatively new things. During the Middle Ages and the early Renaissance these unfortunates were driven out of communities to perish miserably or were executed as witches. The

[1] A convenient synopsis of the statistics and their interpretation is to be found in the recent volume of Landis and Page entitled "Modern Society and Mental Disease."

Bethlehem Hospital in London was founded probably in the thirteenth century and has had a continuous history since that time, but for centuries after its opening stood alone as an "asylum" for these unfortunates. Parenthetically, it may be noted that the word "bedlam" is a corruption of Bethlehem, the name of this hospital. One can well imagine the reasons why when it is realized that only the "furiously mad" were confined in institutions, that little or nothing was done for them even in the line of elementary hygiene, and that these places were scenes of the worst types of filth and confusion.

The first public mental hospital in this country, at Williamsburg, Virginia, was founded in 1773, but it was not until the middle of the nineteenth century that the practice of building public mental hospitals became general, thanks to the activities of Dorothea L. Dix. The purpose of these institutions, which were then known as asylums, was primarily to care for the "furiously mad," as they were denominated. The more quiet patients were often cared for in jails or in almshouses, a situation which is not unknown in some parts of this country even to-day. It may be pointed out and emphasized that mental disorder was early looked upon as being of public interest only in connection with the disturbance of the peace or with "pauperism"; it was a subject to be dealt with by the police or by the poor authorities, not as a medical problem. Historically, these facts are probably connected to some extent with an attitude not entirely unknown, that mental disease impresses some sort of "stigma" upon the person who suffers from it and upon his family. Indeed, even to-day in many parts of the country the mental hospitals are under the control of departments of public welfare; that is, under organizations which are designed primarily to deal with the dependent, rather than raised to the dignity of recognition as medical institutions. The development of the medical attitude toward mental disorder, the attitude that we are dealing with disease which should be treated by physicians and which is amenable to treatment, is relatively recent. It is this evolution which has brought about the change of name from "asylum" to "hospital," with all that that name implies.

In the early days in this country admission to mental hospitals was not especially difficult, although those who were able to pay for care avoided, so far as possible, being sent to the public institution. The "asylum" was designed, as we have said before, primarily for "paupers" and for those who had been considered dangerous to the public peace. In the beginning hospital admission was a simple matter, but in the '50's the "railroading myth" seems to have become established. As a result of the fear that persons would be improperly sent to mental hospitals and there detained for the purpose of permitting others to obtain control of their property, the admission to mental hospitals was in a good many states made decidedly difficult, and some went so far as to require a trial by jury on a charge of lunacy before the patient could be admitted to the hospital. Such a barbaric and antiquated procedure was abolished by statute in the District of Columbia only as recently indeed as 1938, and is still retained in at least one state. There are many people to-day who believe seriously, in spite of the overcrowding and the constant pressure by hospital administrators to dismiss patients from hospitals, that patients are actually sent to such institutions improperly. Any one who has had experience in the administration of mental hospitals knows that this is a most

untrue accusation, yet laws still exist which make it difficult for patients to enter mental hospitals, although admission to any other kind of hospital is very simple. When admission is made difficult, and particularly when a jury trial (which often appears to the patient and to the public both to be in the nature of criminal proceedings) is necessary, admission to a mental hospital is delayed and often the best chance of cure of the patient is lost. The existence of the popular notion of "railroading" has done much to delay the early admission of patients and thereby to deprive the mental hospitals of one of their proper functions. Again it should be pointed out that in some localities it is permitted to use the jail for temporary care of mental patients until such time, sometimes several weeks or months, as the mental hospital finds room for the patient. Such proceeding is, of course, seriously out of line with sound practice and is grossly unfair to the mentally afflicted patient.

Some of the feeling that mental disorder is something apart from general medicine, that it is something which labors under a stigma, is perhaps due to the way in which psychiatry has been presented and in which in the past mental hospitals have been operated. There was a time when the asylum with its forbidding wall made no effort to overcome in the community the attitude of suspicion which was directed toward it by those ignorant of its activities. The "asylum doctors" were looked down upon by the physicians in the locality and an atmosphere of hocus-pocus and of something mysterious tended to keep people away from the institution, both physically and mentally. In medical schools the student was given the impression that mental disorder was something not akin in any way to the rest of medicine; the lectures were the most sketchy and sometimes not even accompanied by a visit to the mental hospital, with the result that physicians have in the past not been in a position to assist in breaking down the public distrust. To-day we find psychiatry integrated with the rest of medicine in medical training. We find medical students spending much of their time in mental hospitals, working at close quarters with the patients and coming to realize that psychiatry is something which touches every other field of medicine. They realize, too, from what they see in the institutions that they are not the places of horror and misery which some even to-day seem to consider them. Further, many general hospitals are establishing psychiatric wards—a decidedly salutary step in bringing psychiatry and general medicine into closer union.

Another misconception has been that once a patient was admitted to a mental hospital all hope was lost, and there are many who think that the inscription described by Dante over the gates of the Inferno is written, even though invisibly, over the entrance of mental hospitals. Such is, of course, far from the case. Mental disorder does not warrant the attitude of hopelessness which the public ascribes to it, even though certain types of mental disorder have not so favorable a prognosis as have others, and although in general mental disorders tend to take somewhat longer for their cure than do the disorders which take patients to general hospitals. Most readers will probably be astonished to learn that during the year 1933 for every one hundred patients admitted there were forty-six discharged, of which number thirty-nine were considered recovered or improved. Of those discharged 22 per cent. had been hospitalized for two months or less, 55 per cent. for less than six months, 74 per cent. for less than one year, and 87 per

cent. for less than two years. Furthermore, it has been found that at the end of ten years over one half of the patients discharged are living in the community, a small proportion of them, to be sure, having had in the interval one or more readmissions to mental hospitals.

It should be understood that mental disease is not a unitary thing; there are many different types, some of which occur early in life, some in middle age and some in advanced years. The discharge rate and the prospects for these various types are not all alike by any means. This is true likewise of the symptomatology. The average citizen probably thinks of the mentally disordered person in the terms of a "raving maniac," one who is disturbed, noisy, disheveled, annoying others, possibly even making homicidal attacks, and so on. As a matter of fact, patients of this type constitute perhaps not over 5 per cent. of the population of a mental hospital. Some patients are depressed, some are confused, some are apathetic, many show relatively little disorder of conduct. Some of this difficulty is perhaps due to the legalistic notion that a person is either sane or insane, and to the rather fixed definitions, most of them entirely out of line with psychiatric thought, which the law gives for that legal term "insanity." Mental disorder represents a failure of the individual to adjust to his environment, but such adjustment depends on many things: it depends upon his heredity and the constitution with which he was born, on his training, on the functioning of his ductless glands, on the situation with which he is confronted, his education, his native endowment and many other factors. In some instances we have degenerative processes due to old age, in others we have brain disease due to infection or intoxication, and it is quite obvious that with so many varying factors the types of reaction and the manner in which adjustment fails will vary. Mental disorder is not necessarily accompanied by disease of the brain, although brain damage often produces mental symptoms. It is rather a failure of adjustment of the entire personality. "Mind" is not a unit, but rather an abstraction which symbolizes the sum total of the reactions of the individual at the social level.

A few words may be in order concerning some of the broader general types of mental disorder which find their way into hospitals. One of the important groups is that due to degenerative processes, that is, hardening of the arteries of the brain (cerebral arteriosclerosis) and senility. By the very nature of the disorder, the outlook is poor. Together these types make up about 18 per cent. of the admissions to mental hospitals. As for the future, a factor which can not be overlooked is the changing composition of the age groups in the population. Human life is lengthening, the birth rate is falling, immigration has almost ceased. Furthermore, the incidence of mental disease increases steadily as age advances; the rates of mental disorder for the respective age groups of the population are somewhat more than four times at age 80 what they were at age 20. Whereas in 1900 only 4 per cent. of the population was over 65, at present 6 per cent. is over 65, and it is estimated that by 1980 somewhere between 14 and 16 per cent. of the population will be over 65.[2] In other words, there is every reason to believe that the number of patients in mental hospitals suffering from cerebral arteriosclerosis and from senile psychoses will probably increase rather materially as time goes on. It is difficult

[2] "Problems of a Changing Population," National Resources Committee, p. 25. Washington, 1938.

to see how very much can be done about this.

There is another group due to the infections, of which general paresis is a conspicuous example. This disorder is one of the late results of syphilitic infection, and until about twenty years ago was considered to be a rather promptly fatal disorder once it had reached the stage of calling for hospital care. During the world war considerable impetus was given to the campaign against syphilis, and the campaign has been carried on since, having been given more recently a very strong reenforcement through the splendid efforts of Surgeon General Thomas Parran and the symposium organized and presented by the American Association for the Advancement of Science. Already the effects of the twenty-year-old campaign are being realized in a fall in the admission rate of general paresis; it is confidently to be expected that as time goes on the rate will fall still further. Furthermore, since very striking advances have been made in the treatment of this disease through the fever therapy devised by Wagner-Jauregg, the prospects of this group, which now constitutes about 9 per cent. of first admissions, are good.

As an example of another group of mental disorders we may mention that due to intoxications; the alcoholic psychoses are a type. Although a drop in admissions for this type of disorder began about 1914, apparently as the result of the campaign against the excessive use of alcohol, and although there was a sudden drop in 1920 when prohibition went into effect, there has been a rather gradual rise since 1920, with the result that we are approaching the pre-war levels in the admissions of alcoholic psychoses, now about 5 per cent. The educational program against alcohol was badly disrupted by prohibition, and it will take a number of years to make this effective again. Ultimately some drop in the rate of alcoholic psychoses is perhaps to be expected. Mental disorders due to other drugs, such as opium, cocaine and marihuana, are relatively negligible. Admissions due to head injuries are rather infrequent; although mental disorders sometimes ensue following head injury, they are generally not sufficiently disturbing to call for commitment to mental hospitals.

There are some types of mental disorder which have no uniform and clearly demonstrable organic bases. They are, perhaps, constitutional in predisposition and environmental as far as precipitating factors are concerned. With the group of depressions, which account for about 12 per cent. of first admissions, some progress has been made with "shock therapy" in recent months. These depressions are rather inclined to spontaneous recovery and usually do not call for a long hospital residence, except for that relatively small group which occurs during the involutional period and in which the duration is somewhat longer and the prognosis somewhat less favorable. Another large group and very important one is that of dementia praecox, or, as it is frequently termed, schizophrenia. On account of the relatively early age at which this tends to develop and the rather long course which it is inclined to run, nearly one half of the population of any mental hospital is found to be suffering from this disorder, although the first admission rate is only about 20 per cent. Much research work is being carried on in the field of schizophrenia, and a little progress has been made recently through the so-called "shock" treatment. Many baffling problems are still presented, however, and the future is not entirely clear. It is felt by those experienced in this field that much

depends upon preventive activities, which will be touched upon later.

The question is often asked whether mental disorder is increasing. The warning should be given that the only reliable statistics are those of *hospitalized* mental patients. We have very inadequate means of knowing how many cases of mental disorder there are in the community. Consequently, if a state provides inadequate facilities and makes it extremely difficult to enter a hospital, it may boast of a low mental hospital rate. If, on the other hand, it is progressive, as New York State is, providing ample facilities, a large proportion of those in need of care will receive it. The discrepancy among the several states in the rate (per 100,000 general population) of the patients hospitalized is enormous, the figures for New York and Alabama being respectively 464.5 and 163.5. It may be said very briefly that there appears to be a slight general rise in the admissions to mental hospitals, and a slight increase, rather steady, in the population of these hospitals. It is questionable whether at the present time, at least, the prospect is alarming. The figures which have been given for the trend in the senile and arteriosclerotic groups, however, certainly seem to indicate heavier future demands for mental hospital facilities.

Much used to be said about the influence of heredity in mental disorder. That there is such a thing as heredity can not be denied, but it is not looked upon to-day as one of those inescapable things to which one may as well surrender without a struggle. The growth of the mental hygiene movement has laid stress upon the importance of attempting by proper training, guidance and environment to overcome native handicaps, and much can be done in that line. As for environment, it is quite likely that the constantly increasing pace of life has no particularly beneficial effect upon the mental hygiene of the public; on the other hand, it can not be proved to be the principal factor in any increase in mental disorder. The old myth about farmers' wives, who were generally reputed to be particularly susceptible to mental disorder, has long since been exploded, and it has been found that the rates for hospitalization are in general slightly higher in urban than in rural communities. This, however, may be due in large measure to the fact that peculiarities of conduct are much less well tolerated in closely settled areas than they are in rural districts, with an increasing likelihood of commitment.

The modern mental hospital is as far different from the old asylum as could well be imagined. It is a general hospital thoroughly well equipped, surgically and medically, to deal with any physical disorders which may arise among its patients. It is equipped in addition with occupational therapy, with hydrotherapy and other specialized forms of treatment designed to remedy the disordered mental attitude of the individual. Padded cells have not existed for many years, and seclusion and restraint have long since been virtually abandoned, having been found to have a deleterious effect on patients. As much freedom as possible is given to patients, and the atmosphere of the hospital is one as nearly approaching normal community life as can well be secured in an institution. There are various types of entertainment and social activities, all designed for the purpose of helping the patient to readjust himself to mingling with his fellows in a normal way. Recently considerable attention has been given, partly for economic reasons, to the possibility of caring for the mentally ill in families after the more acute problems have been dealt with in the hospital. The

system of family care, which was first introduced into Massachusetts in 1885, has at last been adopted by several other states.

It should not be thought, however, that all mental hospitals are the ideal places that have been described. Unfortunately some states have been decidedly backward in their care of the mentally ill, have been niggardly in the appropriations voted, and have allowed partisan spoils politics to interfere with efficiency and with the securing of adequately trained and interested personnel. It is to be hoped that the new interest in public health now being fostered by the Federal Government will bring about improvement in those states in which it is needed. Mental hospitals, in addition to their intramural activities, are engaging constantly more and more in community activities, particularly with relation to child guidance and adult mental hygiene clinics. These activities are extremely important from the preventive point of view, being designed in the case of children to overcome habit difficulties, and in the case of adults to prevent mental breakdowns in those who appear to be showing symptoms of incipient difficulty. Mental hospitals, or at least the more progressive ones, are centers of research and of teaching—a trend which is rapidly developing.

Even the most vigorous opponents of "state medicine" have always admitted that the care of the mentally ill is a proper function of government. As the public becomes more acutely aware of the true importance of mental disease in the community and of the needs of hospitals administering to this group, we may look to see the standards raised and greater efficiency brought about in the humane care and treatment of the mentally disordered.

THE CURSE OF ANGKOR

DEATH COMES QUICKLY IN THE TROPICS

By Dr. ALFRED C. REED

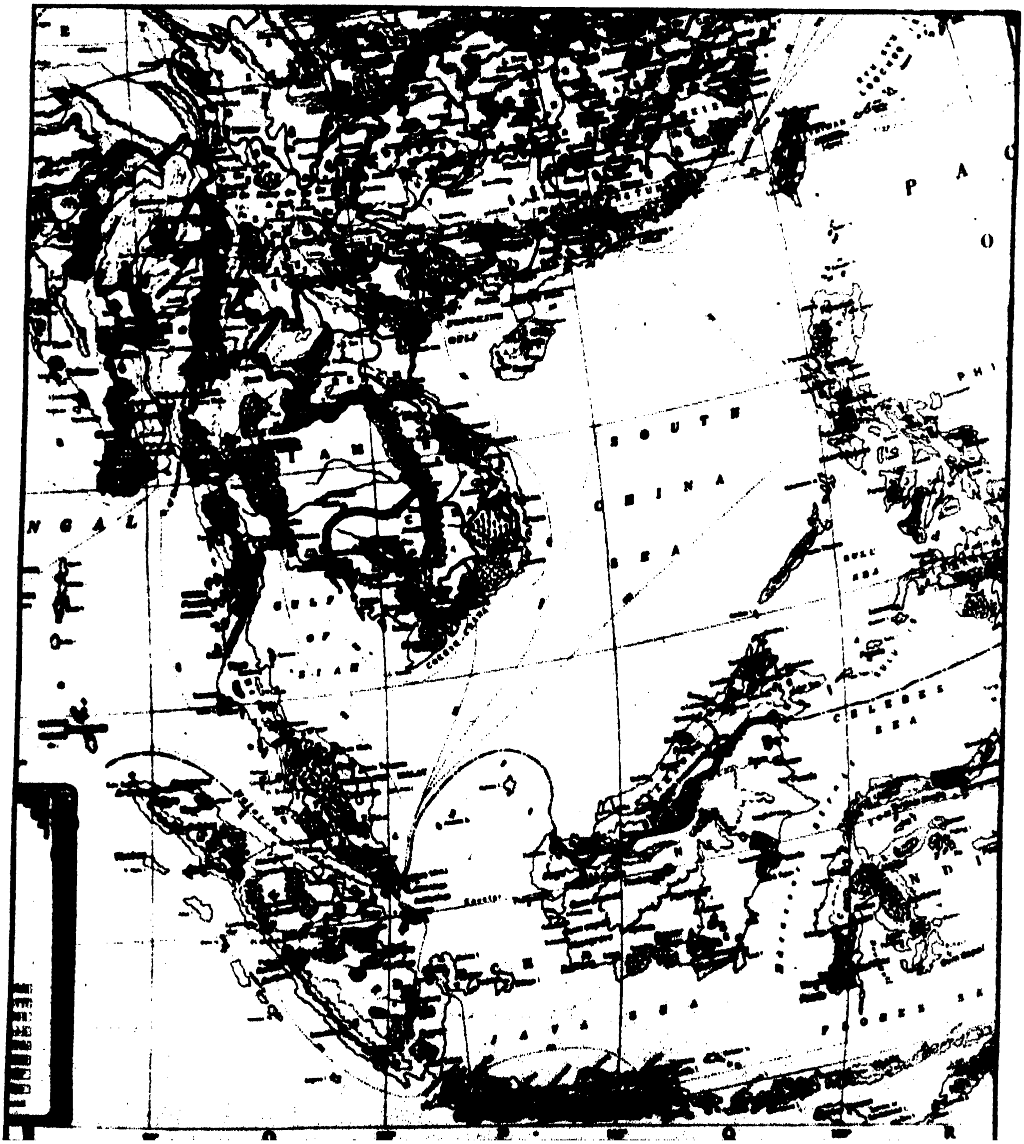
PROFESSOR OF TROPICAL MEDICINE, UNIVERSITY OF CALIFORNIA

WE have a long journey before us, across many thousands of miles and many hundred of years. We stand on the muddy black bank of the Great River, the Mekong, 2,000 years ago. A shadowy figure squats before us looking at some yellow grain in his hand. He is Dak of the Jungle, and he is here because of a dream in which My Lord, the King of the Cobras, ruler and owner of the land, directed him to leave his thatched hut, high on stilts above the jungle floor, and go to the Great River, where a new magic would be revealed to him. As he looks stupidly at the grain in his hand, a second figure stands beside him, a dark, lean, tall man in outlandish garments. The stranger asks Dak about what he is looking at, and Dak patiently tells of the dream and the useless grains that he finds in his hand.

The newcomer is Prince Cambu (Chandu) from the land of Arya Deca (the Deccan of India), driven out from his ancestral home by long drouth. His wife, Mera, the foster daughter of Siva, had died, and his people were destroyed. He paid close heed to Dak's story, looked sharply at the yellow grains Dak was about to throw away and saw a vision of a new race in the fertile valley of the Mekong, raised up for the glory and worship of the gods, through this magic talisman, Rice. His vision saw the jungle pushed back to the further hills and replaced by solid fields of rice, than which no other crop can feed more mouths, saw cities and villages, a great and powerful empire, and turned with Dak to seek out the Cobra King for permission to establish himself in the land. He married the King's daughter, the serpent princess, who, being immortal, took on her the lovely form of a beautiful woman. And so, as runs the ancient story, the Khmers came into the land from India, replaced the jungle with its chiefest enemy, rice, and grew into a mighty nation. And the Sons of Cambu, the Camboga, gave their name to the land of Cambu, Cambodia.

History dimly records the steps of the old folk myth. In the centuries preceding the Christian era, a stream of immigrants from India came into the delta regions of the Mekong and the Menam. By the fifth century, A.D., the Khmer race was established in these lower valleys and was beginning to spread northward. In the thirteenth century it reached its greatest glory. At the end of the ninth century, Yasovarman, the thirteenth king of the serpent dynasty, built the new capital city of Angkor. He was the Leper King, referred to in the sculptured rocks and from whom the terrace of the Leper King to-day derives its name. Ankor Wat was built a century later. Its roots were in Brahma and the Sanskrit language. It drew increasingly from the arts of China. It is the race of half-hidden mystery that left as its sole monument the remarkable ruins of Cambodia.

But to return to the legend, where truth is always being rediscovered as it is released from the cerements of allegory and symbolism. The serpent princess, who became the wife of Cambu, was immortal and ageless, Cambu fulfilled his years and his place was taken by another, but the queen was young and fair as ever. It became her custom to espouse each succeeding king, as only thus could



MAP OF SOUTH CHINA SEA
WITH SIAM, INDO-CHINA, HONGKONG, MANILA AND SINGAPORE.

CHIEF GATE ANGKOR THOM
REMNANTS OF BUDDHA-LIKE GIANTS IN STONE AT SACRED NAGA.

she watch over the Khmers who were her children and whose land was her father's. She returned to her cobra-form by day and only at night appeared to the king as his first wife, whom he must visit each evening before he saw any of his other wives. Thus through the story of the Khmers runs the dark and elemental cult of the snake.

At this very point we must pause to note the significant fact that in all the monuments and ruins of Cambodia the serpent, the cobra, the Sacred Naga, plays a prominent part. Not only do the folklore and mythology of Cambodia go back to an original ownership of the land by the Naga, but the very fact of this ownership and recognition in story points to still older origins. The oldest of these is found in Hinduism, which is based on the supporting power of the primeval cobra, from which was derived this earth and its inhabitants. Serpent worship runs like a dark thread through all the mazes of Hindu literature and belief from the earliest to the latest. When Buddhism raised its head from the fold of Hinduism, the Sacred Naga again became active, and we find the Naga supporting and sheltering Buddha at the time of his enlightenment, so that the seven-hooded head of the cobra becomes one of the symbols of Buddhism. Thus in Angkor, we see the cobra, first the faithful servant of Siva, then of Buddha, and finally of the new culture on the banks of the Mekong.

Similar to the spread of the cult of the snake to Cambodia, was its spread from Hindustan to Egypt. Miss Helen Gordon Barker (personal communication) states that, in the Egyptian hieroglyphics, the cobra occurs constantly with body erect and hood expanded. Its name "ouro" signifies "king." It is also in this position on the headgear of

the pharaohs of ancient Egypt and on the head of Tutankhamen in the temple of Luxor (fourteenth century, B.C.). Miss Barker quotes R. P. Knight ("Symbolic Language of Ancient Mythology," 1876) as follows: "The sort of serpent most commonly employed by Egyptians, Phoenicians and Hindus is the Cobra di Capella, naga, or hooded snake. It is the hooded snake, which we believe to be a native of India, from whom Egyptians and Phoenicians borrowed it and passed it on to the Greeks and Romans."

The "Encyclopedia of Religion and Ethics," edited by James Hastings (1912), says: "The Cobra serpent was much reverenced in prehistoric times, when it appears as a house amulet to hang up, or as a necklace amulet, or coiled round a stick, or in pairs twisted together. The cobra with expanded hood became the emblem of judgment and death, and appears on the cornice of the judgment hall and on the royal headdress." The hooded snake, the Cobra di Capella or naja, is found up to an 8,000 foot elevation all over India from Ceylon to the Himalayas. The closely allied naja haje is found over a large part of Africa and, according to the Encyclopedia Britannica, it was the asp of the Egyptian divinities.

The story of the cobra of Angkor thus is related to the story and meaning of the medical caduceus and the symbolism of the serpent in Greek, Roman and Phoenician philosophies. The serpent as a symbol is world-wide. The Hopi snake-dance, African juju and the Voodoo worship of Haiti, the serpent in the garden of Eden and the plumed Mayan serpent of ancient Mexico have origins and meanings probably all dating back to the sacred naja of India. And back

ELEPHANT TERRACE IN ANGKOR THOM

A REVIEWING STAND FROM WHICH NOBILITY LOOKED DOWN ON ANIMAL SHOWS AND MILITARY SPECTACLES.

HEADS OF COLOSSI
IMMORTAL GUARDS ON THE AVENUES APPROACHING THE CITY GATES.

of that lies the cult of the snake, old as man himself, and derived from the matriarchal society which beheld in the snake the symbol of the male influence. In it was joined the knowledge of good and evil which alone gave eternal life.

The story of the snake, therefore, gives a strong clue to the origin of the people who settled the ancient valley of the Mekong. Their first origins must have been in India in Hinduism, and later this must have been overlaid by Buddhist culture from the north, from either China or Tibet directly. At the time of their destruction, their temples contained only one great figure and no other images, indicating that Hinayana Buddhism then as now reigned in the land.

Aside from the incompletely deciphered carvings of the ruins, our chief and, in fact, almost sole source of information of this ancient kingdom is from the diary kept by a Chinese traveler, Chow Ta-quan, who visited Angkor and lived there for some time about 1296 A.D. At this time the country was at the height of its power and glory. The great city itself, inhabited by a million or more people, was the center of a populous plain, in which cities were scattered about through the rice fields. The forest and jungle were driven back, the timber being used for construction of the common houses of the common people, and for scaffolding necessary for the erection in masonry of the great temples and houses of the nobility, whose ruins stand to-day.

The old Chinese traveler said that no saws were used in construction, but only hatchets, all wooden beams being hewed out from the tree trunks. East and west of the city itself were two great tanks or reservoirs, filled from the same stream which now flows past Angkor Wat and down through the village of Siem Reap.

These great reservoirs are now covered with paddy fields, and the jungle surrounds them. In the city itself the tall temple towers bore flagstaffs, with streaming banners and pennants, and the city itself was magnificently decorated with gold, presenting a spectacle of wonder to the travelers and wandering tribes of the vicinity.

The wide extent of cultivated fields was necessary to support the large population, as well as being a direct result of forest clearance to secure timber. It is a striking fact that in the buildings of a permanent nature stone was brought for vast distances and used by the methods of the wood builder and not the methods of the masonry worker. It is apparent that the construction ability of the people was originally that of handicraft in wood. When they turned their attention to stone construction no new principles were developed, but the old methods were used, resulting in no use of the mason's art and in architectural features which will be mentioned later.

In their general style there was some suggestion of the architecture of ancient Egypt. The Egyptian pylon can be seen by the imaginative eye in the lack of the use of a keystone or true arch by the Cambodians. The weight of the superstructure was supported on a lintel by walls which sloped outward almost to the extent of external buttresses. In these side walls the stones were overlapped inward more and more until finally they were crossed by a long stone at the top. In fact, the entire use of the stone suggests that these people originally were woodworkers and applied to their stone constructions the principles they had already learned in wood.

Chow Ta-quan looked with admiration at the lavish use of gold for decoration, apparently in the same fashion that it is seen to-day in Japan, Siam, Burma and elsewhere. Angkor had two golden

DOORWAY SHOWING LACK OF ARCH CONSTRUCTION
NOTE ALSO EARTHQUAKE DAMAGE.

DETAIL OF CARVINGS IN ANGKOR.

towers, a golden bridge, golden window frames in the council chamber of the king and a special golden audience window in which the king sat. The dwellings of the nobility and of priests faced east. In the palace itself was a golden tower in which the king slept. Here the spirit of a nine-headed cobra lived, and in it was vested the absolute ownership of the kingdom. This cobra appeared to the king every night as a woman, and the king's death was foretokened by the non-appearance of the cobra on any night. He described the king's dress as including a golden crown, which was a high pointed diadem similar to those of the dancing girls depicted in the stone carvings. Garlands of jasmine and other flowers were worn, and on his neck nearly three pounds of pearls, besides bracelets and golden rings. The soles of his feet were bare and, like the palms, were stained red. Then, as now, it was customary for the noble ladies to stain their palms and soles red, although the soles of the feet were invariably concealed from sight as a matter of decency. The king was the only man who had a similar privilege.

Our reporter states that the king had five wives, one a chief wife, and the others representing the four points of the compass. He had heard tell also of there being three to five thousand concubines. With customary racial prudence, Chow Ta-quan looked askance at the excessive bathing habits of the Cambodians. "The people often are ill. Their too frequent bathing and excessive washing of the head has much to do with this. Often they recover unaided. Many lepers take up their position on the road, but, though they live and eat with them, people do not catch this illness. They say it is a disease they are accustomed to in the country. Once there was a king who caught it, but he was not scorned for that. In my humble opinion it is excesses in love and abuse of baths that bring on this illness." "They have no coffins for their dead but only matting. They cover them with a sheet. When they get far outside of town to some uninhabited place they leave them there. The rest was for dogs and vultures. Some were already beginning to burn their dead. These latter were all descendants from Chinese." It might be added that this is still the customary method of disposing of the dead in Chinese Turkestan and elsewhere in Central Asia, whence the custom probably came to Cambodia.

Chow Ta-quan deplored the number of Chinese at Angkor, because it decreased their prestige. The Cambodian populace he thought very simple because of the respectful fear they showed the Chinese, prostrating themselves to earth before them and calling them Fo (Buddha). Miss Wheatcroft, in her book, "Siam and Cambodia," gives much description from this old traveler and other sources about the ancient kingdom of the Khmers. Her volume is decidedly worthy of perusal, and acknowledgment is made for the reports used here, especially from the old Chinese traveler.

Outside Angkor City is the great temple of Ta Prohm. Here Miss Wheatcroft describes the stele which lists the temple dependents in the days of its glory. There were altogether 79,265 persons attached to Ta Prohm alone, of whom 12,640 lived within the temple enclosure. There were 18 officiating priests, 2,740 secondary priests, 2,232 assistants, including 615 women dancers. Within the temple confines there must have been streets of wooden and bamboo houses, such as are seen to-day in the adjoining village, Siem Reap. There are also records of well-organized hospitals on the temple grounds with doctors, nurses and assistants, both men and women. Part of their duties consisted of the care of the aged and sick among the pilgrims and worshippers. One record states that 102 hospitals were in operation in Cambodia in the year 1186.

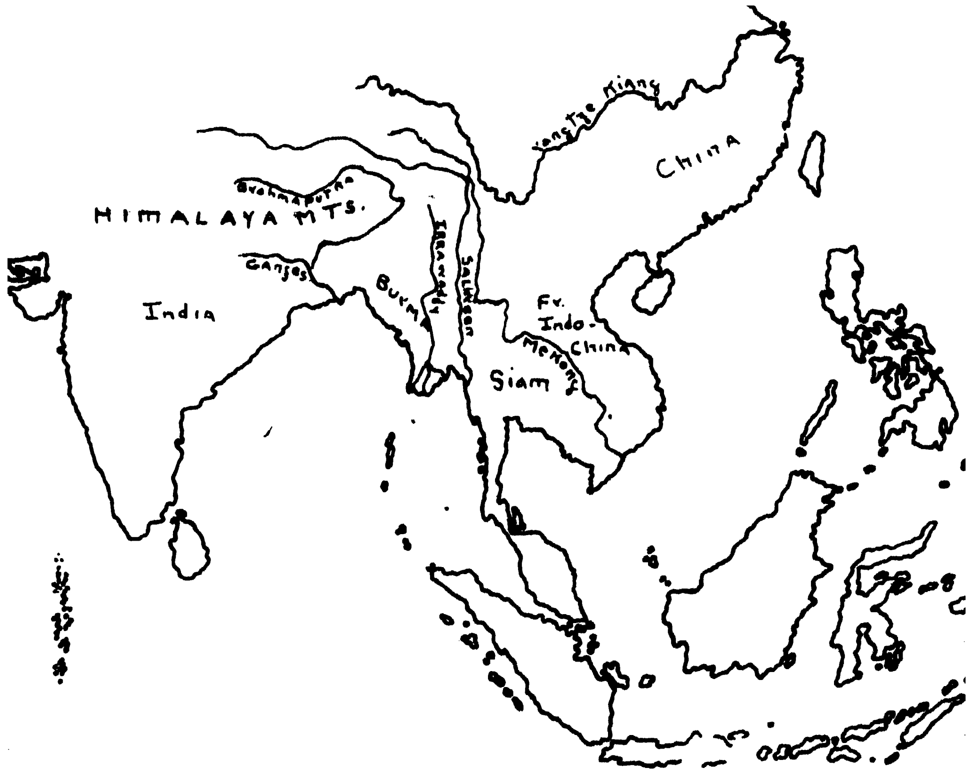
In our day Cambodia fascinates the traveler with its monuments of past greatness. Let us look at it under the prosaic sun of the twentieth century.

Close around the eastern end of the Himalayas sweep five torrential rivers. They drain Tibet and bring down a turbulent flood of life-giving water and silt from those ancient mountains which look down upon the earliest home of mankind and of human culture. Not only do these five great rivers bring silt and moisture to the receptive earth of the southland, but also there flows down from the same high table land a stream of myth and ancient folk ways, whose influence has spread in the past throughout the low countries of southeastern Asia, across the great islands, into Australia and out over the Pacific almost to the New World.

Nearest of these five rivers to the height of the Himalayas flows the great Brahmaputra, which curves back on to the plains of India and touches the delta of the Ganges. The angle between the Brahmaputra and the Salween is filled by the basin of the Irrawaddy flowing down serenely through its jungles, past Mandalay and the Shwee Dagon pagoda of Rangoon. Close to it to the east comes also from Tibet the mighty Salween, signalized to English-speaking readers by the Moulmein Pagoda near its mouth. These last are the rivers of Buddha, as the Brahmaputra is the river of Siva and Hinduism. Of the five great rivers, the two easternmost flow together to form the Father of Waters, the Yangtse Kiang of China. Here Buddhism also, like a flood, has overwhelmed the land and spread on in militant form into Japan. In between these two great courses of influence and culture and physical power, we find, curving also around the easternmost end of the great mountains, the River Mekong, which takes a more southerly path and carries the same things from Tibet to the great plains of Siam and Indo-China.

The lower valley of the Mekong curves around toward Saigon on the lower China Sea. It lies between Siam on the north and west, and the great French province of Annam on the east. It ex-

PRIMITIVE CAMBODIANS OF TO-DAY
THE BABY CONTINUED TO SUCKLE WHILE THE MOTHER FOLLOWED THE TRAIL CUT BY THE MURDEROUS KNIFE OF THE BOY.



THE FIVE GREAT RIVERS OF SOUTH-EASTERN ASIA.

tends down to the Gulf of Bangkok and the lower country of Cochin China. Its capital is Pnom-Penh, as it has been for a millennium or more. It is called Cambodia.

French Indo-China lies in a most strategic relation to the Pacific Ocean and to Asia. Its capital and mighty fortress of Saigon lies equidistant from Hongkong and Manila, by nine hundred and fifty miles, while Singapore is six hundred and fifty miles to the south. Facing the Philippines across the China Sea, Saigon and the richness of Indo-China lie, as it were, between the great jaws of the British Lion at Hongkong and Singapore. Because of this, the jaws can never close and politics must constantly charge the atmosphere.

Cambodia is to-day as flat and floor-like as during the millennia of its past history. The river Mekong winds in long undulations through it, and in flood spreads out broadly over its territory. In ancient days it was a rice-raising and rice-eating country, therefore, a country of enormous population. In present days the population is low, indeed, but rice culture is returning and the jungle, which has intervened for six hundred years, is rapidly being pushed back.

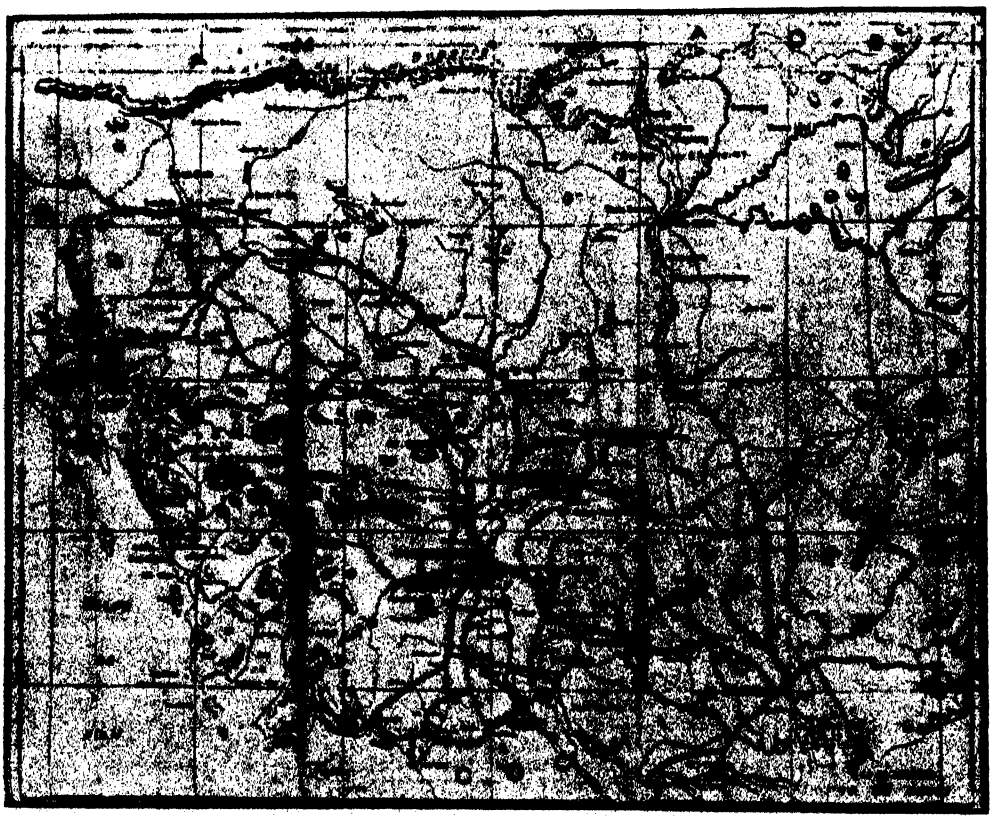
The visitor to Angkor may start from Saigon by motor car, going to Tayninh on the Pnom-Penh road, and then turning north over good roads to reach the Mekong River at Kampong Cham for the ferry. Across the river, one soon joins the high road from Pnom-Penh north to Angkor. From Saigon this journey can easily be made in one day. By special arrangement it is now possible to fly from Saigon to Angkor, but who wants to fly over Annam and Cambodia?

The alternative route is from Bang-

kok. The wheezy little train leaves Bangkok at 7 A.M., reaching the Siamese border station of Aranya Prades at 4 P.M. For five hours the country is flat as a floor, little above sea-level and devoted to rice culture. Paddy fields, marshes and canals cover the landscape. Sampans and canoes go everywhere between the fields. The little train stops at the slightest provocation. The engines, as all over Siam, burn wood in place of coal or oil, which are not found in the country. Every station has long platforms piled high with endless cut wood which coolies noisily load on to the tender. Showers of sparks and charcoal pour from the engines.

Water buffalo adorn the countryside in great numbers, attended by numerous small white herons, especially when grazing or lying in water holes. It is a drab and uninteresting journey. At noon one enters a different terrain. Tall, white, sepulchral trees are interspersed with bamboo thickets and patches of jungle. Low hills and rolling plain become largely devoid of cultivation. There is always a good breeze, which still allows clouds of mosquitoes to invade the car. Siam is oppressed by mosquitoes and poor sanitation in spite of the glowing disclaimers of its native sons.

Aranya Prades is four miles from the frontier and in the last open country before the jungle, which stretches northward to the mountains and China and eastward to the China Sea. A small rest house provides clean and comfortable rooms and American coffee, always a thing to be devoutly wished for in French and British lands. Aranya Prades is left behind at 7 A.M. by auto-



CAMBODIA AND THE ANGKOR DISTRICT.

A ROYAL CORNER SHOWING DOOR CONSTRUCTION.

mobile. The French border station of Poipet marks the entrance into Cambodia. At low water, Angkor is four hours distant around the northwest end of the Tonlé Sap, which is a great fresh-water lake, attached to the Mekong River like the gall-bladder to the bile duct. At high water, however, one follows a rough, hard, metalled road 280 miles southeasterly to the Cambodian capital at Pnom-Penh. These French roads are excellent in their engineering and furnish the only means of communication, except by water. They are roughly surfaced and the available French cars seem quite devoid of springs and ride on small high-pressure tires, making an ensemble which is hard on disposition but doubtless an excellent tonic for the liver.

This country of western Cambodia is the home of the white rhinoceros, the cobra and various other death-dealing beasts. For the first half day it is open, with patches of rice fields, clusters of trees, but mostly dry, barren upland, flat to the horizon. Half way to Pnom-Penh, patches of jungle begin, occasional hills, many rivers and small streams, more and more palms, and gradually a scattered forest in places dense and attractive. In general, one does not care to repeat the journey for scenic effects.

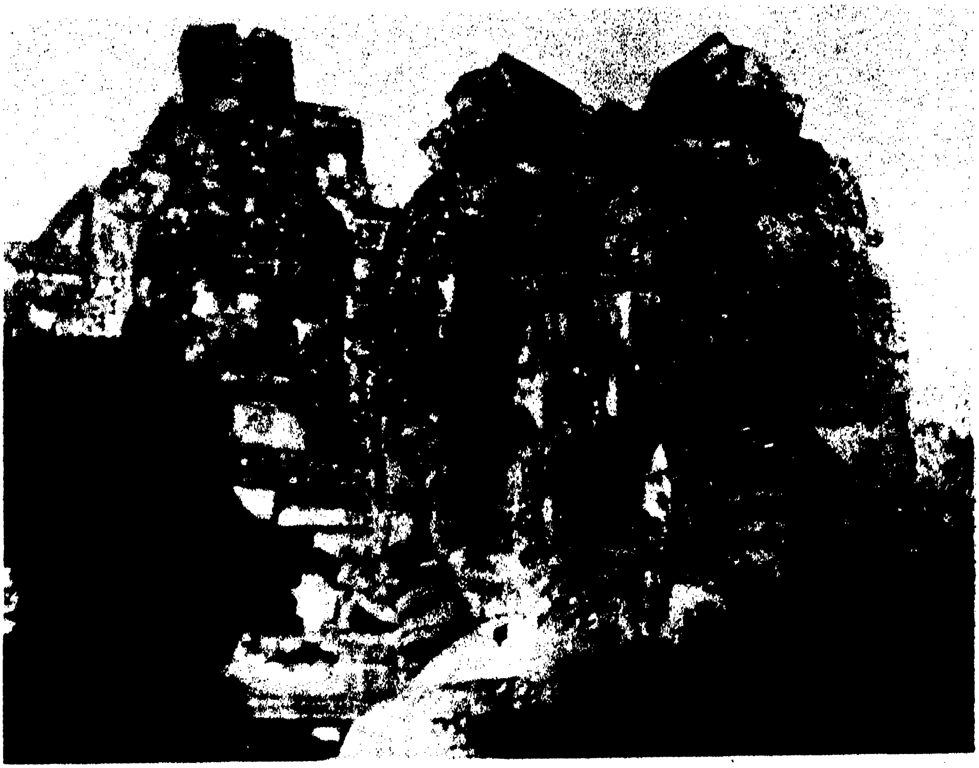
Pnom-Penh is a dirty, cluttered French colonial town with a fascinating past and a tawdry present. Except for the Cambodian Museum, one can omit it without loss and with much mitigation of discomfort and poor food.

Leaving Pnom-Penh at 6 A.M., the road overlooks the great Mekong River from a broad dike along which is a succession of villages, set in dense tropical forest and shrubbery. After 20 miles, the Mekong is crossed on a weird flat-

boat, ferried the half mile across by an asthmatic launch. At ten o'clock Kampong Thom is reached, where is a good rest house with fit food to refresh the traveler and wine to make light his heart. But by carrying crackers and bottled water, no stop is necessary, and after all, one does not really want to stop just three hours from Angkor. The landscape for the entire two hundred miles is flat as a table, spreading over the rich alluvial valley of the Mekong. The bird life is remarkable. Thousands of herons, secretary birds, cranes, pelicans, kites and crows rise in swarms ahead of the car, wheel lazily about and settle back to their duties of commissary and meditation. Brilliant colors are matched by grotesque shapes. Flamingoes live westerly toward the Tonlé Sap.

Rice growing gradually gives way to jungle and forest. Water increases. Monkeys abound and the trees re-echo their speech. The countryside becomes a rich jungle with interspersed rivers, and clearings set with paddy fields and villages. The vegetable mass of the jungle is 20 to 30 feet deep, above which towers a glorious forest, chiefly of hardwoods, including teak and mahogany. In overgrown clearings are tangled masses of bananas and palms. The slender, graceful areca palms are unusually tall. Bamboo grows in thickets and clumps. This remarkable tropical plant, together with palms and mangroves are most characteristic of the tropics, and, like the palm, the bamboo is most vital for man's life there. Alfred Russell Wallace defined the tropics as those lands where the palm is indigenous. Its hundred and twenty-five varieties serve man in nearly every one of his needs. They provide food, raiment, protection, building material, condiment, intoxicating beverage, stimulating drug and

A COURT IN ANGKOR WAT.



THE FOUR FACES OF SIVA ON THEIR TRIPLE TOWERS.

many other requirements. The same is true of the bamboo. The uses are unnumbered. Its mere beauty justifies its life. Practically every human need from food and shelter, to weapons, pumps and storage receptacles, is met from this remarkable plant.

Cambodian villages are built chiefly set high on stakes or piles to keep the houses above flood level. The house itself has a low roof of nipa thatch, small windows and a floor of slender poles or bamboo. A village resembles a cluster of bird houses.

The road skirts the small town of Siem Reap and three miles further on the three great towers of Angkor Wat suddenly leap above the level sea of forest. Just across the great moat from the temple is the pleasant and comfortable Hotel des Ruines, strung out in low buildings connected by covered passageways. Some two miles to the north lie the remains of Angkor Thom, the capital of the Khmers. Well over a mile square, the ancient wall stands to-day enclosing palaces and temples, whose stones have been laid back under expert direction so that the great city can be visualized in its resurrection from the living tomb of the jungle. Whether one sees the silent and implacable ferocity of the jungle, or whether one sees the buoyant life and fertility, makes the difference between a green hell and an opulent home for man's future. The difference lies exactly in the strength and availability of the master hand of scientific medicine which alone bends the tropics to the support, comfort and progress of mankind.

Six hundred years are shed with the jungle itself, as the French archeologists have literally exhumed these ruins from their green death and one sees the an-

cient glory of the place with the remarkable fact that no funerary relics are found. Straight clean roads traverse the fifteen-mile square in which lies Angkor and its outlying temples. Outside the city, roads lead past stone squares, some covering forty to sixty acres, and not yet released from the jungle grip. These are buried in deep, dark forest, with projecting and alluring angles and corners of temples, shrines, pools, gardens and beautiful rock carvings.

As sunset nears, a sudden deafening chime, like myriads of electric bells, sounds the evening anthem of the cicadas which swarm through the trees. The hum and buzzing of a general insect chorus are set off against the croaking and deep booming of multitudinous frogs. The chattering of monkeys and the clear, mellow calls of the geckos complete the orchestral vespers. With the darkness comes complete silence.

Across from the hotel terrace stand several elephants, at the service of strong-jointed travelers, while against the darkening eastern sky rise the dull brown towers of the great wat, behind the dark waters of the sacred tank. Yes, it is magnificent. It is overwhelming. It oppresses. It cries aloud of another world, and the ghosts of the past are almost visible. In fact, they are entirely visible. A straggling torch-light procession comes with the darkness. Odorous resins and balsams have been collected by the village children and bound into bark torches. The wavering light and the incense smoke lead one in silent fascination to follow the procession across the great elephant causeway, where the torches are reflected from the portentous waters of the tank, over to the massive façade of the wat, silhouetted against a star-lit sky paling in faint moonlight.

The torches make a semicircle of footlights. The music of ancient Angkor comes from the orchestra of tom-toms

PRESENT-DAY CAMBODIAN HUT,
PROBABLY SIMILAR TO THE COMMON HOUSES OF ANGKOR.

AN ISOLATED SHRINE
IT STILL RESISTS EARTHQUAKE AND JUNGLE.

and wooden drums, with a quaint and very sweet flute and wooden notes like a zither. Verily the pipe of Krishna played there before the old temple walls, to breathe once more the air of man and dance once more to the glory of Siva.

The girls were dressed elaborately in rich satin costumes and tall headgear, barefooted with heavy silver anklets. One man took part in mask. Wonderfully graceful children added their part. The Cambodian dances are slow and graceful, consisting mainly of posturing, bending and stately pacing. The use of the hands and arms is expressive to an unbelievable degree. All is symbolic and narrative, meanings largely lost in the dim mists of tribal memories coming down to the present villagers. Such a scene is not soon forgotten, the stage setting of temples and sky, the incense torches, the grotesque and bizarre dancing, the weird and poignant music and the Cambodian faces roundabout intently watching. It is easy for the imagination to drift to other days of Siva and Buddha, and a world vastly younger and immeasurably wiser in the lore of the spirit.

To visit Angkor is to be overwhelmed with the tremendous extent of the ruins, their remarkable preservation in spite of jungle, earthquake and weather, their somber and compelling beauty, and the exquisite perfection of the innumerable miles of rock carvings. The distances are great, and the dangerous Cambodian sun makes it necessary to ride between them. The houses of the common people have disappeared. Great forest trees and penetrating roots and creepers have made havoc. The footprints of earthquake are visible, but enough remains of massive masonry and great piles of structure to show the magnificence and extent of the originals.

GIANT DIPTOCARPUS
IT GROWS ON TOP OF AN EXQUISITE STONE SHRINE ENTWINED BETWEEN ITS MASSIVE AIR ROOTS.

OLD GATE SUPPORTS FOREST GIANT
ITS HUGE AIR ROOTS STRETCH FROM THE OLD ENTRANCE GATE ACROSS LONG STONE PAVEMENTS TO FIND SOIL.

One example may be detailed. From the auto road at one place a narrow path leads a quarter mile, winding among 200-foot trees, 6 to 10 feet in diameter, growing out of an impenetrable tangle of smaller trees, vines, creepers, brilliant flowers and undergrowth. Suddenly high rock ruins appear across an ancient stone causeway, which leads over a tank now dry and overgrown. At the end of the causeway one penetrates through an entrance tower or pagoda, and then a narrow, dark gateway through a carved stone wall into the temple itself. It is totally invisible from a distance of fifty yards. The temple towers a hundred feet high, the solid masonry covered with a heavy growth of trees, vines, creepers and shrubs. Monkeys howl and chatter on every side. Within the temple are many long corridors of cells where the priests lived. These all radiate from a central high stone tower in which is the image of a reclining Buddha. All the walls are frescoed with bas-reliefs, in which the figure of Buddha appears over and over again. Many inner courts are beautifully shaded by giant trees. Most of the great pile has not been cleared sufficiently to permit access, but enough is in evidence to fill the spectator with awesome wonder at the architectural ability and the art of those old builders.

In front and overlying the temple itself were two gigantic diptocarpus or fromager trees, whose enormous roots, six to ten feet in diameter, crawl like prehistoric pythons across hundreds of feet of masonry pavement, until finally they find access to the soil. In the rock carvings here, as all through the Angkor district, lies a rich commentary on the history, culture and customs of the Khmers.

A visit to Angkor is incomplete with-

DIPTOCARPUS AND SHRINE
AN EXQUISITE COMBINATION OF LIVING DEATH AND DYING LIFE.

PUSHING BACK THE JUNGLE
NATIVES SAVE THE RUINS FROM A GREEN DEATH AND RESTORE STONES TO THEIR ORIGINAL PLACES.

out climbing the high central tower of the great wat and from the topmost terrace watching the sun sink into the green-black sea of the jungle. Gradually only the western sky is alight, and the spirits seem to walk again in the courts and colonnades of the huge sanctuary at one's feet which gradually sinks back into the oblivion which has buried it for 600 years. A few Buddhist monks have crude quarters in one court. Otherwise only the innumerable bats are bestirring themselves in countless millions, preparing for the night's work. Their twittering and stench are almost overpowering in the dark corridors and halls. Perhaps they are in reality the manifest stirrings of those evil forces which conquered Angkor and which, even yet, keep so much of the tropic world in bondage.

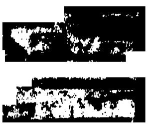
One leaves Angkor in the freshness of the morning for the return to more prosaic things. Three hours bring Kampong Thom, with its clean rest house and a substantial lunch. Then the new road turns off to Kampong Cham and the breathless work of ferrying the car across the broad Mekong. New roads of excellent construction lead on down to Tayninh, and sixty miles more through villages, paddy fields and forest, bring Saigon and the choice food and coolness of the Continental Hotel. Sitting under electric fans on the outdoor terrace, with every convenience and comfort, one is again in a Paris set down in the soft evening air of the tropics, among palms and orchids, with a busy, colorful street demanding attention and questions of steamer and money-changing obtruding. Angkor grows remote and hazy. Its influence departs. It becomes a misty dream, of half-imagined, half-remem-

bered fantasies. But to the thoughtful traveler, its name will always arouse inarticulate memories and a consciousness of something deeper than speech and more intimately portentous than the sounds and sights of the work-a-day world.

The ruins of Angkor Thom stand a mile and a half square, with a wall in almost perfect condition to-day, and the temples and royal houses inside still in good preservation. It is dominated by the great Bayon Temple, with its fifty towers and hundreds of rock-carved faces. The great square pillars of the lower terrace have on each side three dancing apsaras, whose lithe grace is seen even in the Cambodian dancing girls of to-day. A mile or more outside Angkor Thom is the renowned Angkor Wat, or Great Temple, originally dedicated to Siva, and then the overflow of Buddhism turning its worship toward that of the Master of the Yellow Way. Originally there is no doubt that the great central tower, which was open to worshipers on all sides, housed the lingam of Hinduism. Now this tower is divided into four recesses, the one facing west having in it a bronze Buddha of great beauty. In fact, a small Buddhist community lingers still within the confines of the outer enclosure.

The Wat is built of gray sandstone on foundations of laterite in enormous blocks. It is covered throughout, inside and outside, by the most meticulous carvings in low relief, depicting, presumably, the history, achievements and personal grandeur of the rulers of ancient Cambodia. One series of these carvings refers to the conquest of Siam. Finally, in turn, Siam revolted and conquered the mother country, carrying off the Emerald Buddha of Angkor to Bangkok. The Cambodian king then became a vassal of Siam until the French Protectorate was established in 1867.

GIANT TRUNK AND AIR ROOTS OF A DIPTOCARPUS.



CHIEF ASCENT IN ANGKOR WAT
SHALLOW, HIGH STEPS LEAD STEEPLY UP TO THE HIGHEST TOWER.

The outer enclosure, which is over 6,000 yards in circuit, is crossed by a huge causeway for elephants made of enormous stone blocks and leading a quarter of a mile across the great surrounding moat of the inner temple. Traces of gold and gilt decorations are still to be seen in places, and originally there must have been a shining mass of metal used in decorations and representations. The main group of buildings consists of three great tiers of galleries. Groslier, quoted by Miss Wheatcroft, says that the Khmers excelled in artistic skill, but were deficient in invention, as shown by the endless repetition of patterns in the carvings. Groslier refers to the latest-built of the great temples, the Angkor Wat, as the Triumph of Intelligence, because of the symmetry and perfection of its planning as a whole. He calls the Bayon the Triumph of the Soul, because it shows signs of gropings after change.

Groslier says the Khmers were not architects and were lacking in the science of building in spite of the luxurious civilization of the tropics in which they lived. They were great artists, but their construction principles were rudimentary and showed no evidence of improvement as time went on. From India the Khmers took their intellectual endowment in religion and mythology, but their use of stone was limited by their previous knowledge of the use of wood, as for instance, for beams and boards and the support of superstructures. In India it is common for the low temples to be surrounded by high gopurams or entrance-gate towers, while at Angkor the Holy of Holies is under the central, highest and most magnificent tower. However, the vast influence of Hindu mythology is seen throughout the bas relief, and in the very structure of the temple with the surrounding ceremonial tank or pool of holy water. Strangely enough, in all the miles of Angkor carvings, there is no obscene figure, in striking contrast to the conspicuous obscenity of Hindu temple decorations in India.

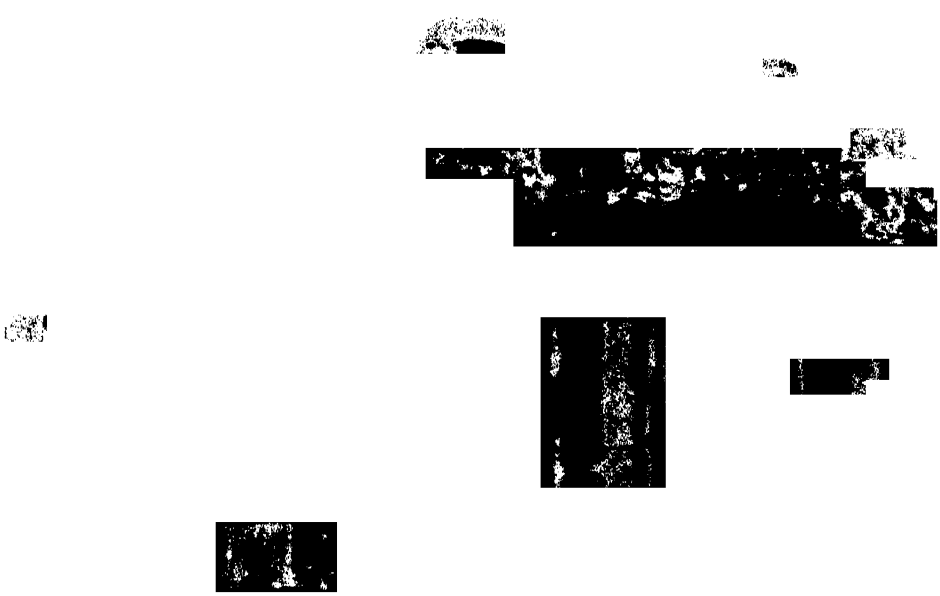
The Khmers brought their more material civilization, evidently, from China. This probably came in with the first great wave of Buddhism. Weights, measures, all matters of practical everyday living, came from South China, or even from Central Asia, and were direct accompaniments of Buddhism.

The old history of organized hospital medical service is an interesting commentary on the recognition in those times of the need of combatting disease. This recognition points to the existence of disease as a real problem. It is safe to infer that the great stream of pilgrims came from distant Buddhist lands and that the temple worship, then as today, gave opportunity for the spread of contagious diseases among the worship-

pers and their epidemic distribution by returning pilgrims. They indicate that tropical disease played no small part in the downfall of Angkor.

It is an astonishing thing that an empire of the magnitude, richness and culture shown by Angkor in its glory, should have made so small impress on the world of that day and finally should have been completely lost to human knowledge and destroyed without more records in adjacent countries. Consideration of story, legend and written history, so far as it can be deciphered from the rock carvings, indicates that in the thirteenth century the Siamese and other Thai tribes to the north were tributaries to Angkor. Constant wars against these and against the Chams to the east went on for centuries. Eventually these barbarians overcame Angkor.

It is impossible to believe that a city as rich and powerful as Angkor, in a country as populous as ancient Cambodia, could suddenly be wiped out by revolt of one particular group of people tributary to it. There must have been predisposing causes. We have in this connection to remember that history does repeat itself, and that the same is true of cycles of disease. Epidemics and pandemics come with fair regularity, and the course of civilization has, on the whole, been influenced more by disease than by purely political and military causes. Applying these principles to the story of Angkor, we are forced to the conclusion that disease conditions of some sort weakened the people to the point where rebellion was possible on the part of the Siamese, with destruction of the mother country. In no other way does it seem possible to explain the complete disappearance and destruction of this wealthy, populous and powerful empire, sunk without a trace in the green-



EARLY MASONRY

STYLE IN DOORS AND BUTTRESSED WALL POINTS TO WOOD-WORKERS AND NOT MASONS.

ery of the jungle, with no clue to the cause of its disappearance either in its own ruins or in the records of surrounding nations. The mystery of Angkor ranks with that of Easter Island, of the Zimbabwi ruins in Rhodesia, of Borobodor in Java and of the pyramids of Yucatan.

Death comes quickly in the tropics, strikes with little preliminary preparation, often with slight warning, and frequently leaves no trace of its passage. The fate of Angkor, the curse of Angkor, is to be found, therefore, in that sudden pestilence which walketh in the darkness of the jungle and which struck at noonday on this fair city and nation with such disastrous results. We know that Greece and Rome fell before malaria. We know that Egypt fell before hookworm and Bilharzia. We know that the tsetse fly swerved the host of Islam northward out of Africa into Europe. We know that Panama fell before yellow fever and malaria, and so through a list of major historical events. To put an exact name on the curse of Angkor is not possible, because there are no records as to what type of disease afflicted the people in the years preceding their military conquest by the Siamese. We do know from the general study of medical history, however, that diseases now important and dangerous in this same locality and in the Far East in epidemic form were undoubtedly present in those early days, and among them furnish the cause of Angkor's fall. Leprosy is mentioned by the old Chinese traveler, Chow Ta-quan, as being exceedingly prevalent. It is so to this day. Leprosy, ordinarily, is of such slow development and spreads so slowly that it does not assume major importance in the course of empires and political events. However, it may well have furnished part of a disease background which led to disaster. It is always chronic and slow in its course, but its cumulative effect is tremendous, and it can not be excluded from the foundations of the downfall of Angkor.

Perhaps the most important single disease to consider in this connection is malaria itself. This disease to-day is perhaps the most important one to which man is subject, both in numbers of those afflicted, in economic losses, in death rate and in impoverishment of health and happiness. Tropical malignant malaria strikes suddenly, may kill within a day, and in regions which are favorable to its course may depopulate districts with astonishing speed. Here we must place, probably, one of the chief reasons for Angkor's disaster.

The Black Death of India, kala azar, has but to cross from the delta of the Ganges to Burma, to Assam and up into the Malay country in times past and up to the present. Here is a disease of a two- to three-year course, without modern scientific treatment invariably resulting fatally, spread rapidly through the medium of small, biting flies, and attacking entire populations, especially in jungle areas. It, too, can not be excluded from a major rôle in the tragedy of Angkor. Its conquest in the past decade is one of the monumental triumphs of scientific medicine, but in the old days it was one of the very Captains of the Men of Death. The dysenteries and typhoids are always with us, particularly in the tropics, and their rôle could hardly be primary in the situation we are now discussing. The same might be said of the effects of animals and snakes, which by their bites contribute to a considerable death rate. These factors were fairly constant and were probably much less in ancient times with highly cultivated fields than at the present.

The fall of Angkor may well have been hastened also by cholera, which still flows in epidemic waves over the southern half of Asia. Because an efficient

national quarantine keeps the United States free of this disease, we are prone to forget its devastating sway in countries which have no sanitary sense and where the natural causes of disease are unknown and ignored. Finally we must recall the influence of plague, which killed a fourth of the population of Europe in the thirteenth century and which has spread over the world in great pandemics from prehistoric to modern times. Noel's "Black Death" is worth reading. Even the very recent knowledge of the rôle of fleas in carrying plague germs to man from the great rodent reservoirs has not led as yet to complete conquest of this disease. If plague could kill Pericles and pave the way for the fall of Athens at Syracuse, it could also have been no mean factor in the swelling tide of disease that constituted the curse of Angkor.

Sixty years ago, the naturalist, Mouhot, struggled through the jungle of upper Cambodia in search of his game of natural life. By chance he came upon the massive ruins of Angkor, which thus again were restored to human knowledge after six hundred years burial beneath the green waves of the jungle. During that time the only known inhabitants of this great empire were the thousands of monkeys which scampered gracefully about its ruins, the white rhinoceros, the tigers and the abundant waterfowl and other animals which made it their home. A few scattered aboriginal inhabitants, who are probably, without question, the descendants of the ancient Cambodians, were found in scattered jungle villages. Wild as animals and with little except poorly understood folklore pointing back to their ancient ancestry, these people can throw no light on what happened or why it happened.

What the old French naturalist saw, and what the French archeologists have been gradually exhuming ever since, lies revealed to-day in part, with the jungle stripped back and the great stones replaced from the places whence they had fallen, the creepers and vines and impenetrable growth of the jungle torn away, so that we see over a diameter of fifteen miles a scattering of such colossal ruins as are seen in few other places in the world except Egypt.

The story of Angkor remains to be written in its completeness. But from the fragments and outlines now available, we can draw another great lesson from Asia. Death comes quickly the world around where medical science is unknown or ignored. The curse of Angkor has been the curse of many another race and nation. Sufficient knowledge is available to-day to prevent or control most of the disease plagues of mankind. Ignorance, indifference, poverty and superstition have always been as they are to-day, the sub-strata on which Asia has built her economic, social and political structures. Our American nation is 155 years old. Now, in its youth, it may, if it will, avert the fate that has terminated epochs, and submerged or destroyed civilizations of the past. Now it may make sure that the curse of Angkor is not repeated in the curse of America.

THE GROWTH OF NATURAL VEGETATION AS WATER CULTURES

By Dr. DACHNOWSKI-STOKES

PHYSIOLOGIST, U. S. DEPARTMENT OF AGRICULTURE

THE popular interest regarding a series of experiments affecting the growth of crops in nutrient solutions without any soil whatever, and the publicity concerning the methods variously called soilless farming, water culture, hydroponics, or some other term used in magazines, over the radio and in public lectures, have raised the question as to how widely the water-culture method finds practical illustrations in nature.

Laboratory experiments to determine the nutrient requirements of plants have been made by plant physiologists over half a century in several countries. The field is now adequately covered in textbooks used by agricultural schools and colleges and is supplemented alike by tests on the part of students and by research of teachers to determine the limiting factors in plant growth and food production.

The fundamental physiology of plants is the same, whether they are grown in a mineral soil, in an artificial nutrient solution or in organic material such as peat. In all instances, an adequate supply of water, sunshine, air and certain salts is of special importance. In fact, water always constitutes more than one half and usually about three fourths of the weight of plants grown as crops. Almost the entire dry matter of plants, except the portion left as ashes when plant materials are burned, consists of carbohydrates, such as starch, sugar, cellulose, as well as fats, oils and other organic compounds obtained chiefly from carbonic acid gas absorbed by green parts and produced by the plants during daylight with the aid of solar energy.

From what has been said it is evident that water and soluble mineral salts of various kinds form an important raw material, but it is necessary to comprehend their intimate relationship to individual plants as well as to groups, or plant associations, in order to understand the difficulties of hydroponics, or soilless growing methods. Emphasis is laid here upon the work of plants; how vegetation behaves when growing as a water culture, not in artificial tanks but in natural ponds, lakes and streams; what changes are brought about and how the watery environment shapes the course and character of vegetation.

Interesting aspects of these relationships are illustrated by the characteristics of a floating island of unusual vegetation located in Buckeye Lake, near Columbus, Ohio (Fig. 1). The island is known as Cranberry Island, and is utilized as a refuge for wildlife. Its general features, together with an extensive series of field and laboratory experiments, were described by the writer in a volume on the peat deposits of Ohio issued by the Geological Survey of Ohio (Bulletin 16, 1912), and more recently in Volume 7 of the "Handbuch der Moorkunde." The lake is of glacial origin, probably of Wisconsin age. It is surrounded by undulating hills, more or less wooded with deciduous trees. The Ohio State Canal, now abandoned, at one time traversed the county. A dike was constructed in 1830 around the western end and a part of the northern side of the lake. This dike caused the water level to rise eight feet above the original level, the ponded water acting as a reservoir for the canal. Most of the peat-forming swamp forest that extended around the shore was submerged, with the exception of a floating mat which

was completely isolated just off the shore on the northern bank of the lake. The "island" thus formed within the deeper parts of the present basin (Fig. 2) is grounded, but it rises and falls with seasonal variations in water level. Living sphagnum mosses and cranberries now occupy the center of the island, together with certain heaths characteristic of typical sphagnum bogs in northern Michigan. On the shores is a scattered growth of some of the former deciduous shrubs and red maple. Since the many different seeds brought to the island by winds and birds can not establish themselves, the natural vegetation has undergone no changes within 30 years.

Because of the proximity of the island to Ohio State University, it was possible for the writer to make a study of it from various view-points over a period of several years (Fig. 3). These investigations were concerned with the identification of the botanical composition and the characteristics of the early stages of vegetation, and with their coordination with chemical and other conditions in the lake as a water culture and those of the island as a nutrient solution, in which the sphagnum mosses and the maple-alder vegetation are growing.

Origin and Development of Cranberry Island

A clear indication of the origin and the stages in the development of the structural features of the island is furnished by its vertical profiles sections. The American peat-sampling instrument was used, and samples from each foot of material below the surface were taken to the laboratory for microscopic study. On this basis the individual layers of peat superimposed upon one another have the following characteristic composition and sequence (Fig. 4).

FIG. 1. MAP SHOWING LOCATION OF BUCKEYE LAKE AND CRANBERRY ISLAND, LICKING COUNTY, OHIO.

ADAPTED FROM THORNVILLE SHEET OF U. S. TOPOGRAPHIC SURVEY.

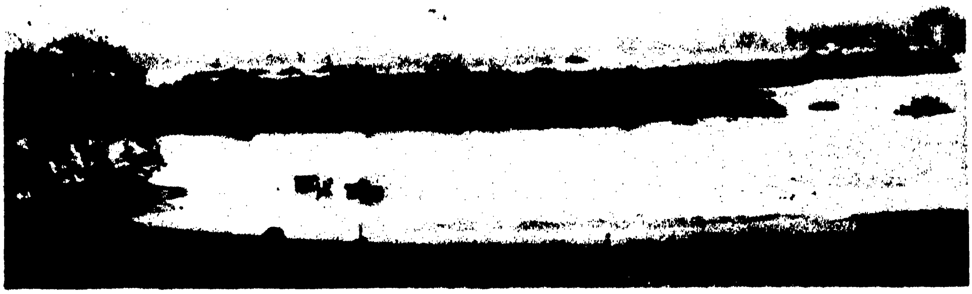


FIG. 2. CRANBERRY ISLAND
VIEWED FROM A HILL NORTH OF THE ISLAND NEAR BUCKEYE LAKE STATION.

The earliest plants in the lake's history were aquatic. They formed an olive-green to brown or grayish-black sedimentary peat. The organic material of which they were composed is completely disintegrated and more or less jelly-like. Under the microscope it shows a wealth of well-preserved plant remains, such as algal filaments, wind-blown pollen, seeds and fragments of pondweeds, and, occasionally, shells, diatoms, sponge spicules, marl from algae and bits of exoskeleton of insects (Fig. 4, A).

In the course of time reeds and sedges encroached, together with cattail. To the exclusion of other forms the tall grasslike vegetation built up a floating fibrous mat composed of innumerable roots interwoven with perennial underground stems. The efficiency of grasslike plants as a growth of this sort in open water without access to mineral soils is particularly obvious in marshes all over the world. The bulk of vegetation forms each year a new addition to the slowly increasing thickness of roots and rhizomes, and thus adds to the formation of a reddish to yellowish-brown fibrous layer overlying the sedimentary peat (Fig. 4, B).

At a later stage a large swamp forest developed. It occupied nearly all the ground along the lake shore, when the first settlement in this section was made. The swamp included deciduous trees and conifers whose root systems penetrated the fibrous peat material which was less saturated and in which partial drainage favored microorganisms, decomposition and mineralization. A radically different kind of peat resulted from the accumulating granular dark-brown woody residue and the fragments of fallen trees, branches of shrubs, leaves and other herbaceous materials of plants that formed the dominant cover of the swamp forest society.

In the great central lowland states generally there is no tendency toward the formation of sphagnum moss bogs. The vegetation stages usually pass through the marsh to swamp shrub and swamp forest. But under certain nutrient conditions, the course of vegetation may turn from the marsh stage to the bog stage. Cranberry Island, in its profile section which shows moss peat overlying reed and sedge peat (Fig. 4, C), justifies this statement.

Nutrient Conditions

The raw materials needed by green plants in water cultures have already been named. They are water, mineral salts and carbon dioxide, used for making, by the aid of sunlight, the carbohydrates and other organic substances that are the food of plants and animals, including mankind.

Natural bodies of open water, such as Buckeye Lake, hold much mineral matter in solution. Part of it is surface run-off from fertile or eroding surface soils and the percolating seepage of underground waters from mineral subsoils, and part is rainfall bringing with it various gases, mineral dust and other impurities from the air. Generally speaking, lake waters are found to contain calcium, potassium, magnesium and other salts, including minor minerals, such as iron, manganese, copper and rarer elements in minute quantities. They contain also carbon dioxide, with which water forms carbonic acid. This carbonic acid greatly increases the solvent power of the water and the chemical activity of the different mineral constituents it contains. Though the water on the margins of a lake may vary in the proportion of the nutrient substances it contains, the quantities in its central parts are kept nearly constant by solution and by free diffusion.

The water near the surface of Buckeye Lake is relatively transparent, while that of the island suggests a dilute-coffee color. The turbidity is due to colloidal organic material in suspension and is common in the waters of many bogs and lakes in northern cooler regions.

During the summer the temperature of the surface water commonly is a few degrees lower on the island than in the lake, the highest temperatures recorded at a depth of three inches being 77° F. and 82° F., respectively. Shading and intercepted air movements kept the water cooler (71° F.) in the maple-alder vegetation. At greater depths, below the surface of the growing roots of plants,

FIG. 3. STUDY PLOT IN CENTRAL PORTION OF CRANBERRY ISLAND
WHERE PROFILE SECTIONS WERE TAKEN AND VARIOUS INSTRUMENTS WERE USED TO DETERMINE CONTROLLING ENVIRONMENTAL CONDITIONS.

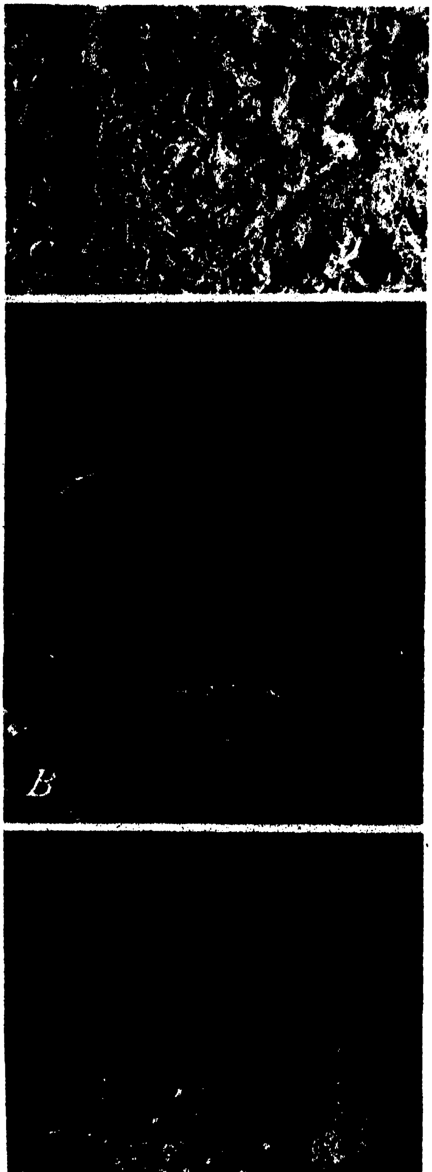


FIG. 4. PROFILE RECORD OF CRANBERRY ISLAND

INDICATING THE GENERAL COURSE OF DEVELOPMENT AND SEQUENCE OF DIFFERENT LAYERS OF PEAT: (A) PLASTIC SEDIMENTARY PEAT THAT ACCUMULATED FROM AQUATIC PLANTS; (B) FIBROUS SEDGE PEAT FORMED FROM A FLOATING MARSH VEGETATION; (C) SPHAGNUM MOSS PEAT WHICH DEVELOPED FROM THE PRESENT STAGE OF BOG ASSOCIATIONS IN WHICH CRANBERRY AND HEATH SHRUBS ARE CHARACTERISTIC.

the temperatures continued lower on the island without interruption throughout the year, while in the lake an annual descent and circulation of the warmer surface waters took place. Consequently resistance to heat changes is greater and layering of temperatures appears to be less interrupted on the peat-forming island than in the open water.

In the clearer water of the lake a considerable quantity of dissolved oxygen occurs, set free by aquatic plants as a by-product of photosynthesis. In the water of the floating island the amount of oxygen available for the roots of growing herbaceous plants is considerably reduced. Free carbon dioxide is present in appreciable but varying amounts at different times, being produced mainly by the decay of organic matter. Often the amounts of gas are greater with increasing depth below the surface. Conspicuous quantities of methane gas in and between roots of plants and layers of peat evidently are an outcome of stagnation and reducing conditions. Gas movement, like water movement, is known to be greatly retarded in peat.

Acid reactions are of particular interest because they have both direct and indirect influences on plant growth. The acidity or alkalinity indicated by pH determinations (pH 7.0 indicates neutrality) show a marked and abrupt change from the slightly alkaline condition (pH 7.5) of the lake water to the high acidity (pH 4.0) in the central part of the island, which coincides with the moss and heath vegetation. The acid-forming colloidal material appears to absorb and retain the basic ions of any salts dissolved in the nutrient solution. It affects the availability of essential elements and the activity of beneficial micro-organisms, and it leads to the formation of products that are poisonous when tested on cultivated plants. Although produced in sufficient amounts to maintain a relatively high degree of acidity, the organic constituents do not

diffuse through the layers of peat and are not transported into the lake by seepage.

The marked difference between the total mineral content of the lake water and that of the peat island is notable. Tests showed that the total solids varied from 309 parts per million in the lake water, to 196 parts per million in the water of the growing sphagnum mosses. In the marginal maple-alder zone the mineral solids increased to 423 parts per million. They represent stored nutrients intermixed with the woody fibrous peat, the liberation of which depends largely upon biological processes of decomposition. This indicates clearly that the absorption and retention of salts by peat materials is very great, creating an unfavorable balance between acid and base elements for absorption by plants. On the other hand, the nutrient solution of the growing vegetation in the interior of the floating island contains a very low total supply of essential mineral salts required for growth. The small amounts that affect growth either are deficient in necessary nutrient elements or they are unavailable because they are locked up in chemical compounds which the plants can not use. The salts from the mineral substratum and from the lake waters do not reach the interior of the island or the surface to supply the needs of the vegetation growing in a water-logged, undrained area of peat.

The small quantity of nitrogenous material derived from decaying organic matter and other sources, such as nitrites, nitrates and nitrogen as free ammonia, ranged from a few thousandths to a few hundredths parts per million, probably because decomposition proceeds more slowly under conditions of a high water table, and the nitrogenous products are rapidly taken up by the growing vegetation. The higher amounts occur in the lake water, pointing clearly to the fact that nitrogenous decomposition products arise mainly through the action of aerobic micro-organisms.

The evidence indicates that various types of natural vegetation, ranging from aquatic plant associations to those of marshes, bogs and swamp forests, are the product of water cultures growing without access to mineral soils.

Combining the major physical and chemical data, determined over a period of several years, with other circumstances prevailing on the floating vegetation of the island at Buckeye Lake, Ohio, it seems necessary to conclude that the maintenance of nutritional requirements favorable to particular plants growing without a mineral soil involves much experimental work and many difficulties. Certain changes occur, the general tendency of which may be designated as a change to acid reactions, which are accompanied by changes in nutrient and other conditions for the growth of plants. Present information does not warrant a prediction as to how widely a water culture method may find practical application for crop production. The maintenance of favorable nutrient solutions requires periodic study of the factors that affect plant growth, cause malnutrition or support diseases. The necessity for changing the nutrient solution to meet the needs of individual crops calls for physical and chemical analyses, continued control and adjustments of culture solutions, and knowledge of elementary principles of ecology and plant physiology. It is concluded, therefore, that the growth of natural vegetation and of garden vegetables or other agricultural crops in water culture is still in the experimental stage, and is not yet ready for practical applications or as a commercial venture.

THE STUDY OF TWINS

By Dr. D. C. RIFE
THE OHIO STATE UNIVERSITY

POPULAR interest in twins and multiple births has grown rapidly in recent years. As a result much interesting information has become available, but at the same time many erroneous opinions respecting the nature and interpretation of twin studies have arisen. It seems appropriate to discuss briefly at this time the twin method of research.

The increasing popular interest in twins is manifested in the formation of Twin Associations, the holding of Twin Conventions and parties and the sponsoring of Twin Contests. It has been the good fortune of the writer to attend several of these events for scientific purposes at the invitation of the twins themselves. One of these occasions offered the unusual opportunity of examining a pair of twins who had been separated for a period of years. Their histories will serve as a convenient introduction to the discussion of the twin method.

On August 16, 1938, 165 pairs of twins held a party at Lakeside, Maine. The party was sponsored by Mr. Welton Farrow, to celebrate a visit from his identical twin brother Harold, whom he had not seen for nineteen years. Because of their long separation and their different environments, the Farrow brothers present cases of unusual value to those interested in the nature-nurture problem. They were kind enough to give the writer their life stories and also to submit to various tests and measurements.

They were born on a small farm in Prince Edward Island on December 10, 1897. Their father was a sea captain, who lost his life during the world war when his ship was sunk by a German submarine. When the twins were ten years of age, their family moved to Saskatchewan, remained there four years, and then returned to Prince Edward Island. In the spring of 1913 Welton went to Portland, Maine, and apprenticed himself to a carpenter, with whom he remained until August, 1914. Then he returned to Prince Edward Island and enlisted in the Canadian militia, serving in the Halifax garrison. In April, 1915, he was discharged on account of fallen arches. Returning to Portland, he spent four more years as a carpenter's apprentice, after which he had to discontinue carpentering because of his fallen arches. For the next two years he was railway Y.M.C.A. secretary for the Boston and Maine and the Maine Central railways. He states that while engaged in this work he came into contact with educated people, and became ambitious for more schooling. Consequently, he entered and worked his way through Hebron Academy, taking a four-year course in three years and graduating in 1922 as valedictorian of his class. He next spent three years in Bates College and then one year in New Hampshire State University, from which he graduated in 1926 with honorable mention. Welton states that mathematics and science were easy for him, but that he had great difficulty with languages. He worked as a carpenter for one year after his graduation. In 1927 he became business manager for Swavely School, of Manassas, Va., holding this position until 1930. From 1930 to 1932 he was superintendent of maintenance for Colby College, of Waterville, Maine. In 1932 he opened a bookshop, which he is still successfully operating. He is married and has one child, a girl five years old.

The life story of Harold is somewhat

different. After the return of his family from Saskatchewan, Harold remained in Prince Edward Island a year longer than did Welton, and then went to Worcester, Mass., where he apprenticed himself to a machinist. In 1916 he joined the Canadian army and was at the front when the armistice was signed. After leaving the army, Harold went back to Worcester, working as a machinist until the spring of 1920, when he went to Winnipeg, Manitoba, where he still lives. While in Worcester, Harold took a course in mechanical drawing at a night school. Harold is still a machinist and, interesting enough, invented and patented a new type of skate sharpener a few years ago. He is married, but has no children.

A glance at the Farrow brothers is sufficient to convince one that they are single-egg, or identical, twins. At the twin party people continually confused them. They have swarthy skins and dark hair and eyes, with no visible differences in degree or type of pigmentation. As shown in Fig. 2, both are bald to approximately the same extent. A comparison of their palm and finger prints revealed the fact that similarities of the two right hands and of the two left hands are greater than that between the right and the left hand of either individual. Plaster of paris impressions of their teeth also show striking similarities. Other physical measurements are given in Table 1.

TABLE 1

	Welton	Harold
Height	64″	64½″
Weight	148½	157½
Blood pressure		
Systole	115	124
Diastole	70	76
Blood group	A	A
Blood type	MN	MN
Unimanual handedness	Right	Right
Bimanual handedness	Left	Right

It is of interest that Harold has never been troubled with fallen arches,

FIG. 1. THE FARROW TWINS. WELTON IS STANDING IN FRONT OF HAROLD.

whereas Welton has been badly handicapped by them at times. Harold has flat feet, however, but not as extreme a case as Welton.

Since they offer rather extreme differences in education, as well as in occupations and environment, the results of the psychological tests of them are of unusual interest. Previous to their separation, each had about the equivalent of a grammar school education. The tests[1]

[1] The tests were scored and interpreted by Professor W. L. Valentine, of the Psychology Department of the Ohio State University.

FIG. 2. ILLUSTRATING SIMILARITIES IN BALDNESS. HAROLD IS ON THE LEFT, WELTON ON THE RIGHT SIDE.

given included the Pressey Test of Reading Speed and Comprehension, the Pressey Interest-Attitude Tests, Thurstone's Scale of Attitude toward War and the Bernreuter Personal Inventory. Their scores are given in Table 2.

The average number of words read per minute was 119 for Welton and 102 for Harold. In reading comprehension, we find that Welton was in the top 10 per cent. of a college population and Harold in the top 20 per cent. The difference of 10 centile range between Harold and Welton is significant and means that Harold is somewhat slower in comprehending what he has read.

Since the twins had been separated for many years, one might expect quite different scores in the War Attitude Test. It does not turn out, however, that there is any significant difference in the twins in this respect, both being definitely opposed to war and warlike measures, as is indicated by a scale value of 3.3 and 3.6, where 6 represents neutrality of opinion.

TABLE 2

	Welton		Harold
Words read per minute	119 lowest centile		102 lowest centile
Comprehension	90 centile		80 centile
Attitude toward war	3.3		3.6
Interest attitude		(College SR.)	
Things thought wrong	+ 7	+12	+3
Worries	0	− 6	0
Interests	− 1	− 5	+7
Likes	−12	−19	−22
Total age score	21 years		21.5 years
Bernreuter Personality			
Neurotic inventory	4 centile		37 centile
Self-sufficiency	69 "		29 "
Introversion	5 "		42 "
Dominance	52 "		46 "

In the Interest Attitude Test we can obtain a total score which gives Welton an emotional age of 21 and Harold one of 21.5 years. This would mean that Harold is somewhat, but not significantly, more mature than Welton. The various subject tests of the Interest Attitude Scale indicate that both of these men are more mature than the typical college freshman, but not quite so mature as the college senior. This is especially true in connection with the "things worried about," where neither marked a single item.

The Bernreuter Personality Inventory gives us four separate scores which do reveal differences between the twins. Both are less neurotic than the usual college population, but Welton is significantly less neurotic than Harold. Welton is also very much more self-sufficient than Harold, as is indicated by a centile score of 69 compared with his twin's of 29. This self-sufficiency test reveals that he does not depend habitually upon other people. The most significant difference exhibited is probably in the measure of scores at the 42 centile level. Neither of the twins is as introverted as the average college student, but there still is a wide difference between them. In dominance, although the difference is somewhat less significant than it has been in the other measures, we still find that Welton is the dominant individual.

To summarize, the tests suggest that the twins are tenacious and profit by whatever experiences they have. They are particularly free from worries, and neither of them is neurotic nor so introverted as the average college student. They differ in that throughout Welton scores higher than his twin, which is not surprising considering Welton's more extensive education. It would be enlightening to know how they would have compared on similar tests previous to their separation nineteen years ago. Of course, these psychological tests, unlike the various anatomical measurements, are subject to considerable measurement error, and although they are satisfactory for distinction between groups of people, they have certain properties that are not entirely reliable for individual diagnosis. We are desirous of obtaining similar data from a sufficient number of separated identical twins to enable us to draw valid conclusions regarding the effectiveness of environment in bringing about variation in the traits measured.

In order to obtain exact information regarding the relative rôles of heredity and environment in bringing about variation, it would be ideal to have for examination twins offering the following four combinations of factors: identical heredities, identical environments, totally different heredities and totally different environments. Thus we could compare the following four types of individuals; those with identical heredities and identical environments, those with identical heredities and different environments, those with different heredities and similar environments and those with different heredities and different environments. It is generally assumed that identical, or one-egg, twins reared together furnish the first type, identical twins reared apart the second type, and fraternal twins reared together the third.[2] Actually, only in the first instance, that of identical twins reared together, do we approximate our goal. With the exception of mutations which may have occurred after separation of the embryos, identical twins have the same genotypes. Their environments are more alike than those of any other paired individuals, due to the fact that their similarities in general appearance are usually sufficient to cause all but close acquaintances to react to them as to a single personality.

[2] On this same basis, fraternals reared apart would furnish the fourth type, but no such studies have as yet been made.

In the case of identical twins reared apart, while having identical heredities, the amount of differences in the environments is highly variable, and in no instance of such pairs as yet recorded have the environmental differences been extreme. If we were interested in determining the maximum differences environment might bring about, we might compare, for example, the members of pairs of African pigmy identical twins, one member of each pair having been reared with his pigmy relatives, and the other by cultured, educated and wealthy Europeans or Americans. Furthermore, the pair showing the greatest intra-pair differences, rather than the mean intrapair differences of the groups, would give us a type of the measure desired. From the practical standpoint, however, we are more interested in how much of the variation between individuals, *on the average,* may be attributed to environment, and thus means rather than extremes answer the purpose satisfactorily. In any statement concerning the part played by environment in producing differences, it is of course essential to specify the type of environment, as well as the type of traits measured. Identical twins reared apart may still have quite similar environments educationally, culturally, financially, religiously and in numerous other respects. The twins we have just described, while reared together, have had unusual differences in education and different vocations and nationalities. Different types of environment are, of course, not necessarily additive to their ability to produce variations. In spite of the abovementioned limitations, identical twins exposed to different environments give us our most accurate material for evaluating the rôle of environment in producing differences.

The assumption that fraternal twins reared together have different heredities and similar environments is the most hazardous of the three. As previously pointed out, identical twins when reared together have more nearly similar environments than any other paired individuals. We react to the members of fraternal twin pairs as two distinct personalities. It is possible that some pairs of fraternal twins have less nearly similar environments, on the whole, than some identical twin pairs reared apart. Comparisons of identical twins reared apart with fraternal twins reared apart should throw light on the problem.

Fraternal twins have, on the average, the same degree of genetic similarity as brothers and sisters. If we desired to determine the maximum differences heredity can produce between individuals, we should examine pairs of extremely different heredities, reared in as nearly similar environments as available, and base our conclusions on the most dissimilar pair. To refer to our former illustration, the natural children of Caucasian pairs, compared with their Negro pigmy foster brothers or sisters, should furnish data of the desired type. But here again, we are more interested in how much difference, on the average rather than as a maximum, may be attributed to heredity. Comparisons of the above type are, of course, not feasible, and, furthermore, it is possible for brother and sister pairs to possess the most extreme ranges of genotypic variation. Nevertheless, the mean genotypic similarities of brothers and sisters are greater than those of unrelated individuals. Thus foster brother and sister comparisons should give us more accurate data for evaluating the rôle of heredity.

Comparisons of fraternal twins, however, furnish data of unique value in nature-nurture studies. Being contemporaries, comparisons with brothers and sisters give us a measure of the degree to which variations between brothers and sisters may be the result of age differ-

ences, although it should be remembered that fraternal twins also have slightly more nearly similar environments. Another important use of fraternal twin data is in obtaining an estimate of the part the unusual prenatal environment of twins plays in bringing about variation. Obviously, due to position *in utero*, crowding and other circumstances, the prenatal environment of twins of each type is different from that of single-born individuals. Handedness is an interesting example of a trait affected by the position *in utero*. In both types of twins the percentage of left-handedness is greater than in single-born individuals. The excess of left-handedness in twins must be due to some prenatal factor operating only in twins.

The observation that the prenatal environment of twins is sufficiently different from that of single-born individuals to be a factor in producing differences in twins emphasizes the need for caution in drawing conclusions from twin data alone. Although any differences present in a pair of identical twins must be due to factors other than heredity, such differences do not imply that the trait does not have a hereditary basis. We have previously mentioned the fact that left-handedness occurs more frequently in twins of both types than in single-born individuals. In about a fifth of identical twins we find reversals of handedness within pairs, that is, one member right-handed and the other ambidextrous or left-handed, or one left-handed and the other ambidextrous. There is definite evidence that an association exists between handedness and the surface patterns of palms and fingers. This with the fact that left-handed parents have a higher percentage of left-handed children than do right-handed parents, indicates that handedness has a hereditary basis. Our data on the handedness of 166 pairs of twins and their immediate families show a significantly higher percentage of left-handers among the relatives of pairs showing reversals than among those pairs having the same handedness. The probable explanation is that those pairs showing reversals are genotypically more nearly ambidextrous than those pairs in which no reversals are manifest, and the unusual position *in utero* is sufficient to shift the handedness of such individuals one way or the other.

In identical twins reared together it is not at all unusual to find slight intra-pair differences in such quantitative traits as stature, weight and I.Q. Ordinarily the same member of the pair is superior throughout, although strikingly similar to his mate qualitatively. Such intra-pair differences are most likely due to conditions *in utero* peculiar to twins, such as an imbalance of blood supply, crowding and other circumstances. Differences of the above type are manifest in the Dionne quintuplets, Yvonne being slightly larger and rating superior to the other in psychological traits, whereas Marie is the smallest and has the lowest psychological rating. Such differences, while not great as compared with ordinary brother and sister differences, must be considered in the analysis of twin data.

Contrary to popular impressions, studies of fraternal twins may indicate the exact mode of inheritance of traits involving only a single pair of factors. Twins are frequently classified as concordant or discordant in respect to given traits. For each mode of single factor inheritance and each gene frequency the ratios of discordant to the various types of concordant pairs can be accurately determined. For example, it can be shown that any trait for which there are only two phenotypes, and in which significantly more than 27 per cent. of fraternal twins are discordant with similar ratios in both sexes, can not be due solely to a single pair of au-

tosomal factors. Unfortunately, data in regard to concordance in twins are usually taken in such a way as to refer only to that concordant type in which both members of the pair manifest the trait in question. Without the percentage of concordant pairs in respect to absence of the trait, fraternal twin data tell us nothing of the mode of its inheritance, for we are dealing with a selected population. For traits in which we are reasonably certain that the differences in degree of similarity of the environments of the two types of twins reared together are insufficient to produce variations, the excess of discordant pairs occurring in fraternal twins over that of identical twins may be interpreted as the extent to which intra-pair differences in fraternal twins may be attributed to their different heredities. For example, Diehl and Von Verschuer recently studied 239 pairs of twins in Germany, in each of which one or both members of the pair had tuberculosis. In the identical twins, 80 per cent. of pairs were concordant, whereas in fraternal twins only 25 per cent. were found to be concordant. The natural interpretation is that 55 per cent. of the fraternal twins investigated are discordant due to differences in heredity, whereas 20 per cent. are discordant, as in the identicals, due to other factors.

But, as we have previously indicated, such interpretations are not necessarily valid for traits which may be easily modified by the similar environments of identical twins reared together. Another German investigator, Lange, several years ago studied both types of twins in regard to concordance in crime. He found a high degree of concordance in identicals, and a correspondingly high degree of discordance in fraternals. These findings are often interpreted as proving that criminal tendencies are hereditary. Obviously, such conclusions are not necessarily valid. If one has an identical twin who is known as a criminal, it certainly is not conducive to good conduct to be frequently mistaken for the criminal brother. Similar studies with twins of both types reared apart would be enlightening.

Numerous investigators agree in finding mean intra-pair differences of approximately five in the I.Q. for identical twins reared together. Newman and his colleagues found a mean difference in I.Q. of approximately 9 points for their twenty pairs of identical pairs reared apart. Hildreth found a mean difference of 14.5 points for brother and sister pairs reared together, and 15.5 for brother and sister pairs reared apart, an insignificant difference. She also found a mean intrapair difference of 17.7 points for unrelated pairs, whether reared together or apart. The greater differences between identical twins separated and together suggests that the similar environment of identical twins is a factor to be considered in the interpretation of I.Q. differences. It is only fair to add, however, that with the exception of the identical twins reared together, the number of individuals measured were too small to give highly reliable mean values.

As previously pointed out, foster sibs reared together *vs.* identical twins reared together should give us a better measure of the influence of heredity than a comparison between identical twins reared together and fraternal twins reared together. Better still, foster sibs of the same age could be selected. But the difficulties in obtaining such pairs are fairly great, and, too, we have failed to take into account the more nearly similar environments of the identical twins. We are attempting the alternative approach to the nature-nurture problem of comparing identical twins reared together with identical twins reared apart or subjected to various types of environmental differences. This gives us an estimate of the rôle

of postnatal environments in producing differences. And we are also comparing fraternal twins reared apart with brothers and sisters reared apart, from which we may obtain an estimate of the rôle of the prenatal environment of twins and also of the age factor in producing differences. That is, if fraternal twins are less nearly similar than sibs, we may assume the difference to be due to prenatal factors; if the fraternal twins are the more nearly similar, age discrepancies are the differentiating factor. Our final group would be unrelated individuals reared apart, or subjected to various environmental differences. Such a group should be easily collected, and the differences between this group and identical twins reared apart would thus give us an estimate of the rôle played by heredity in bringing about differences. By this method we shall furthermore eliminate the problem of determining how much more nearly the environments of identical twins reared together are than those of other paired individuals. Or, better still, such data, when compared with fraternal twin data from those reared together, should give us a means of evaluating the part played by such more nearly similar environment.

The greatest need, and the most difficult to fulfil, by whatever method used, is that of obtaining more pairs of twins reared apart or twins subjected to various environmental differences. But when one considers the fact that there are over 1,000,000 pairs of twins in the United States, about a fourth of whom are identical, it seems premature to assume that all possibilities have been exhausted. The growing popularity of twin conventions and parties and the willingness of twins to cooperate in the collection of data are most encouraging. We earnestly appeal to any one knowing of separated twins, of whichever type, to inform us. We have as yet barely scratched the surface of the possibilities of twin research and its value to mankind.

A SCIENTIFIC BASIS FOR MORAL ACTION

By Dr. MAX SCHOEN

PROFESSOR OF PSYCHOLOGY AND EDUCATION, CARNEGIE INSTITUTE OF TECHNOLOGY

This paper is an exposition of the thesis that a scientific foundation for moral action is not only possible but that it is the only foundation that can bring about results that are at all desirable. A scientific search for moral principles must be guided by four criteria:

(1) That a principle to be applied to man must be derived from man, must be consistent with the facts of man's nature.

(2) That if conformity to a principle can be obtained only by compulsion, of whatever variety, it is an indication that that principle belies human nature, since a principle that is true to the nature of any material is in conformity with that material, and the material therefore already obeys that principle.

(3) That if a principle is consistently violated by the material to which it is to be applied, it is the principle that is false, and not the material that is obstinate. A material can not be wrong, but a conception of its nature can be false.

(4) That if a principle fails to bring about expected or desired results in the realm in which it is applied it is the principle that is at fault and not the realm in which it is supposed to operate. If a medicine fails to cure a disease it is the medicine that is wrong and not the disease. The disease can not be wrong.

Since these four criteria represent scientific caution, it follows that a principle for moral action that is consistent with these criteria has scientific validity. And such a principle in the history of moral theory is found in the Socratic conception of virtue as knowledge as expounded in the Protagoras. The discussion between Socrates and Protagoras arises from the circumstance that Protagoras, a Sophist, a public teacher of virtue, tells Socrates that the young men who come to him for instruction increase in virtue day by day, that every day in every way they get better and better. Socrates expresses doubt as to whether virtue can be taught, which brings about a discussion regarding the nature of virtue. The discussion opens with Socrates raising the question as to whether virtue is like the parts of the face, each of which is independent of the others, in that each can exist without the others, and each of which is distinctive from the rest in structure and function, or whether virtue is like the parts of gold, all of which are of the same quality and can differ only in size. If virtue is like the parts of gold it can be defined, its nature can be determined, in which case it becomes knowledge and can be taught. On the other hand, if virtue is like the parts of the face the virtues can only be named, and enumeration is not a definition or knowledge. To state this differently: if we say that virtue consists of honesty, truthfulness, loyalty, and so on, we know nothing unless we proceed to define these terms and show why they are virtue, which only leads us to a need for a definition of virtue itself. On the other hand, if we have a definition of virtue itself we also have a definition of every specific virtue, since a definition of the whole is also a definition of its parts, a part being a partial manifestation of the whole of which it is a part.

In insisting upon a definition of the nature of virtue rather than an enumeration of the virtues as the way to a knowledge of virtue, and thereby making of virtue something teachable rather than preachable, Socrates brings virtue into the sphere of science, of investigation, of inquiry. And this is inevitable. For the moment we insist upon a definition that is to tell us the nature of a thing in terms of the real thing itself our procedure for reaching such a definition, if we adhere strictly to what we profess to wish to know, must be scientific, for we discard all preconceptions, reject all dogmatic statements, and insist upon verification of results. In so far, then, as Socrates calls for a definition of virtue that consists of a determination of its nature, and rejects a definition that only lists a number of disconnected items each of which itself stands in need of defining, his approach is scientific.

After Socrates had shown that knowledge lies not in enumeration and specification, but in generalization, that virtue must be defined as we would define gold rather than a face, he proceeds to the main issue, namely, if virtue is knowledge, it must lie in the knowledge of something. What, then, is this something knowledge of which is virtue? It is my main purpose to indicate that the conclusion Socrates reaches in answer to this question is also scientific, in that it is supported by what we know to-day about human nature through the science of psychology.

The gist of the Socratic conception of knowledge as virtue lies in such statements scattered throughout the Protagoras as that a person may live inferior to himself, that to prefer evil to good is contrary to human nature, or that it is absurd to say that a person knows what is good but because he is overcome by pleasure he does evil. The implication throughout is that at any and every occasion one does that which one knows, and if the action results in evil it is not because evil was chosen but because the knowledge was defective. Now in what way can a man's knowledge about his behavior be defective? The answer is that he can mistake the lesser for the greater, the immediate for the remote, or, in other words, he can act impulsively or habitually instead of by choice, discrimination or deliberation. When a person acts in the former manner he is acting inferior to himself, in that his action is below his capabilities. And it is action in which something is mistaken for something else, a case of mistaken identity, that leads to evil, since a person is acting under a delusion, and brings about consequences that are harmful to him. But he does not purposefully deceive himself, he does not deliberately mistake the lesser for the greater. The only reason why he does the lesser is that at the time it appears to him to be the greater, that is, the most desirable. The inferiority of a man to himself arises out of ignorance, while the knowledge that spells virtue is the knowledge of magnitudes, of lesser and greater, and the art of virtue is therefore the art of measurement, of discrimination. Socrates' own summary of the conception of the nature of virtue is as follows:

> Now suppose happiness to consist in doing or choosing the greater, and in not doing or in avoiding the less, what would be the moving principle of human life? Would not the act of measuring be the saving principle; or would the power of appearance? Is not the latter that deceiving art which makes us wander up and down and take the things at one time of which we repent at another, both in our actions and in our choice of things great and small? But the art of measurement would do away with the effect of appearance, and, showing the truth, would fain teach the soul at last to find rest in the truth, and would thus save our life. Would not mankind generally acknowledge that the art which accomplishes this result is the art of measurement?

When we translate this philosophical language of Socrates into psychological terminology we find that the definition of virtue as the art of measurement reduces itself to the conception of moral action as action in keeping with human intelligence, that is, a human being living as a human being can live because of his place in mental evolution. It is the mental stature of man that makes of him a moral being. In other words, it is the moral action that distinguishes man from infra-human organisms, and moral action is synonymous with action that is indicative of the operation of human intelligence. To define morality scientifically, therefore, all that is needed is a definition of human intelligence.

The behavior of all animal forms is intelligent, in that it is selective, discriminatory, motivated activity. All that intelligence then means is activity stimulated by the environment, but directed and controlled by the organism itself. The stimulus influences, but does not determine the response. Selective behavior means behavior in which the acting agent is also the determining factor in the behavior performed, so that without a complete knowledge of the present condition and the past history of the acting body no prediction of the ensuing behavior is at all possible from the stimulating situation alone. Since the term intelligence is applied only to the activities of animal life, and since the distinguishing characteristic of animal activity is selectivity, it follows that selectivity is the sign of intelligence, and also that the degree of selectivity of behavior is the sole indication of the degree of the intelligence of the behavior.

Man is the most intelligent of animals because of the degree of selective behavior of which he is capable. The selective behavior of the animal is on a motor level. When a situation presents itself the animal will react to it either by an established habit or it will engage in a series of exploratory movements which will result in the setting up of an habitual response. Even the alleged learning by insight of some of Köhler's apes was on a motor level, in that the insight took place only, if it took place at all, after the motor trial and error had failed. Man is capable of dispensing entirely with motor exploration and to engage only in selective activity that is the fruit of mental exploration, or thinking proper. He can make anticipatory adjustments, can make exploratory movements in his mind, so to speak, and to engage in motor activity only after having reached a decision as to what he really wishes to do. The factors that enter into the making of the final decision are of no importance in the present connection. The important point is that this ability for what we may call delayed behavior by thought lifts man to the pinnacle of selective behavior, namely, knowing what he is doing, because he can deliberately proceed to know before he does.

This ability of man to look before he leaps, and thereby learn by looking rather than by leaping, assumes two forms. Human selective activity can be either activity that consists of discriminated means for the accomplishment of unconsidered ends, or of discriminated ends that necessarily also imply considered means. In other words, the thought problem before the person may be only that of determining the most expedient way of accomplishing a goal that appears desirable, or it may consist of an examination of the desirability of the goal itself. And it is these two forms of human selective activity that lead to an identification of morality with human intelligence. Moral action can not consist in the pursuit

of indiscriminate ends by discriminate means, for such action invariably and inevitably leads to a rationalization of the ends pursued, and rationalization is humanly unintelligent, since the need for it arises from the failure to use human intelligence in its complete form. Furthermore, even if some animals do learn by mental manipulation, its fruit is always the selection of means, never of ends, and consequently, a human being acting in that manner is living on the level of animal and not of human intelligence. To put this in Socratic language, the person who pursues uncritical ends by critical means is ruled by the lesser good, because the immediate good, and therefore acts out of ignorance and not by knowledge. The Socratic virtue of the art of measurement is precisely that of distinguishing between that which appears desirable and that which is really desirable, and that means a discrimination between ends.

A moral act, then, for a human being, is an act in which human intelligence is operating in its complete form, an act for which the person assumes full responsibility, an act performed in full knowledge of what it is all about, and such an act is realized only when the chosen means are prompted by chosen ends. To be moral is to know what you are doing, and to be responsible for what you are doing, because you know where you are going, why you are going there and how you are to get there. It is to live the life that is worthy of a human being to live because he is capable of living it. And this is the life of human intelligence. Man's obligation to be intelligent, which simply means to be a man, a human being, is also his obligation to be moral, which in turn means to indicate by his actions that he is aware of himself as a man.

Thus far I have but indicated that the Socratic conception of virtue as knowledge of lesser and greater makes moral action a function of human intelligence, and therefore makes the science of behavior, psychology, the basis of the moral, or good, life. It now remains to see whether the identification of morality with intelligence is tenable. The evidences to be considered are fourfold: (1) that the view is in harmony not only with moral theory in general, but even with traditional or authoritarian morality; (2) that it is in keeping with the fact that morality is an exclusively human concept and even then only under certain circumstances; (3) that it is confirmed by common experience; and (4) that it is the only view that promises to fulfil the function of any moral principle.

(1) That moral action is impossible without critical knowledge, without the art of measurement, is recognized both by moral philosophy and moral tradition. There is a difference, however, even among moral philosophers, as to what it is that critical intelligence is to be applied to. For Plato, as has already been indicated, the knowledge of good and evil is the knowledge of magnitudes, resulting in the triumph of the greater over the lesser. In Aristotle, who identifies virtue with happiness, in that happiness is the supreme good because it is the end for which all else is desired, happiness is stated to consist in man's power to live the rational life in keeping with perfect virtue, and perfect virtue is defined as the life of moderation or the avoidance of excess and defect. The difference between Plato and Aristotle is that whereas for the former critical intelligence *is* virtue, for the latter critical intelligence *can* be virtue. In other words, the intelligent man of Plato can do no evil, whereas the intelligent person of Aristotle may do evil. In this respect Aristotle is more in the keeping with what we call practical common sense

than Plato, and to that extent Aristotle is probably also wrong. Spinoza, verging on the mystical in his pantheism, nevertheless conceives of virtue to lie in man's intellectual power, reason, which leads to knowledge, to understanding of ourselves. Virtue, he defines, as "acting, living, and preserving our being as reason directs," and "reason desires nothing but to understand, nor does it adjudge anything to be profitable to itself excepting what conduces to understanding." The absolute virtue of the mind is to understand, and only in so far as it understands "can it be absolutely said to act in conformity with virtue." Kant opens his treatise on "The Fundamental Principles of the Metaphysics of Ethics" with the proclamation that "It is impossible to conceive of anything anywhere in the world or even anywhere out of it that can without qualification be called good, except a Good Will." And this good will is good "not because of what it causes or accomplishes, not because of its usefulness in the attainment of some set purpose, but alone because of the willing, that is to say, of itself." But this good will is impossible without reason, in that reason is absolutely indispensable to it, because the good will itself consists in the conception of a law, and this conception is possibly only in a rational being. This law, the conception of which is the supreme good which we call moral, and which serves as principle for the will, Kant formulates as follows: "I am never to act otherwise than *so that I could at the same time will that my maxim should become a universal law.*"

Now, whatever the differences to be found among the moral philosophers, on one thing there is agreement, and that is that human intelligence is the source of moral action, that to act morally is to know what you are doing, which consists of knowing the ends being pursued, and controlling the action to conform to the end. The person planning to rob a bank does not know what he is doing because he has not stopped to examine the end he is pursuing.

Like moral theory, the moral injunctions of the religions, which together constitute the moral tradition of mankind, place moral action in the realm of knowledge. They hold, in agreement with moral theory, that a moral act is an act performed in full consciousness of the end to be achieved. But the end of moral tradition is a legal injunction of superhuman origin to which man is to give his consent and follow without question. By his own intelligence man can not discover his good, but by his intelligence he can learn to know the law, make it his own and demonstrate to himself that to obey it is wisdom, to disregard it is folly. Human reason operates for human good only when it is used to justify God's ways with man. Far apart, then, as moral theory is from moral tradition, both nevertheless posit knowledge as the basis of morality.

(2) When we examine the question as to why it is that no moral significance is attached to the actions of animals, infants, feeble-minded, insane, and even to normal human beings under certain conditions of stress, the answer again is critical intelligence. A man in a rage is not responsible for his actions because he is off his head, does not know what he is doing, although whatever he is doing may be well done. The person with a homicidal mania may show uncanny shrewdness in carrying out his purpose, but he is irresponsible because his purpose is insane. The infant and animal are judged to be neither moral nor immoral, but amoral, because we do not consider them capable of consciously controlled activity, and they are therefore irresponsible. The criterion, then, that we use in making moral judgments

in ordinary daily contacts is then that of critical intelligence: an act being judged moral only when it produces the impression that the acting agent is fully aware of what he is about.

(3) A further piece of evidence favoring the identification of moral action with the art of measurement is the use of the term character as a designation of personality. What is it that distinguishes between the weak and the strong character? The drug addict is a weak character, obviously so because he is ruled by his appetite. He may show no end of ingenuity in obtaining his drug, yet he is a weakling because he fails to control himself by controlling the end. Again, the concern here is not as to the reasons for his pursuit of an uncritical end, the point simply is that the judgment of weakness, with its implication of immorality, or perhaps amorality, is the value placed upon an act that does not involve the functioning in full of what human intelligence is capable. Weakness is sickness, and sickness is a lesser form of health. And when the lesser predominates over the greater in behavior, no matter what the cause, the character suffers, like a person with a physical ailment.

(4) But the final test of the validity of the psychological conception of morality as action in conformity with human intelligence must be in the objective of all moral precepts and principles, namely, the bringing about of a stable, harmonious society. And it can be demonstrated that the conception here presented not only promises to bring about an ordered society, but that it is the one indispensible condition for such a society. This can best be done by seeing whether the ills of society are not directly traceable to the operation of the very principles of moral tradition that are proposed for their cure, because these principles violate the criteria set down at the outset as the axioms of moral truth.

That society is sick, and that traditional moral precepts have failed to cure it, is not denied by even the most uncritical and fanatical supporter of supernaturalism in moral thought. But he will deny that the failure demonstrates the falsehood of his principles, but rather indicates the obstinacy and natural depravity of man. According to the moralist, what is needed is not a change of principles, but bigger and better enforcement of them, that is, more authority for the authoritarian. But this attitude violates all four axioms, in that a valid principle, that is, a principle derived from a material, does not have to be forced upon that material, because it already obeys it as the substance of its being. The fact, then, that a moral principle has to be defended, in other words, rationalized, is an indication that it is a false principle, and that is the reason why it calls for force to be put in operation. And the application of such an arbitrary principle to a material by force can only produce a distortion of the material. Besides, if a principle is concocted out of pure air, the realm of that principle becomes the playground for any one attracted to it, with the result that a horde of contradictory principles arises each of which is to be established as superior to the rest, and while the physicians quarrel the patient is passing out. The ailments of society are therefore implanted and aggravated by the medicines that are prescribed to cure them.

Another count against traditionalism is that it defines virtue, as did Protagoras, by enumerating the virtues, and calls this enumeration knowledge. It calls upon human beings to be honest, but does not define honesty, to be truthful, without defining truth, with the result that any one particular virtue becomes anything one finds convenient to

practice, just so long as he attaches the right name to it, and a label becomes a sanction for a practice, and pretty words substitutes for works. Thus the delusion arises that giving consent to a phrase transforms one into whatever the phrase represents, because that which the phrase represents, whatever it may be, or is supposed to be, is virtue. The fundamental question of morality, namely, that if human beings are to be taught to practice virtue it is necessary to ascertain its nature, traditionalism ignores.

The conception of moral action as critical intelligence, on the other hand, begins with a definition, which is the first step in any scientific procedure, and the definition itself is scientific in that it consists of a principle deduced from the material to which it is to be applied. It states what human action can be, rather than what it should, ought or must be. Since it defines virtue in terms of human nature it is consistent with human nature, and therefore true. Such a principle human beings can violate only by not living up to it, and if they fail to live up to it, it is because of ignorance, not out of obstinacy due to depravity. According to this principle, what human beings need in order to be virtuous is instruction rather than compulsion. A virtuous human being is one who lives as a human being can live because that is his nature. From this standpoint a good man is no different from a good potato. A good potato is one that adheres to the nature of a potato, that is all that a potato can be, that lives up to "potatoness." A poor human being is, again, like a poor potato, a potato that is not everything that we know a potato can be, that falls short of being a potato in its fullness. Morality as human intelligence thus obeys the criteria of scientific truth, namely, it is consistent with the facts, with the human material from which it is derived. As such it coordinates, orders and harmonizes human beings in their interrelationships, that is, socially, since in any coordinated whole a part that functions in a manner true to itself is also acting in a manner true to every other part, and therefore true to the whole.

ADAPTATIONIST NAÏVETÉ

By W. L. McATEE
BIOLOGICAL SURVEY, U. S. DEPARTMENT OF AGRICULTURE

WRITINGS on adaptations, especially those on protective coloration, embody more fantasy than has been regarded as tolerable in any other branch of biological literature. Well known among such fancies is that a certain butterfly pupa, appearing to show a glistening drop of its own blood, is protected by this subterfuge suggesting to possible predators that the pupa has already been attacked and abandoned as unpalatable. Another is that caterpillars having "eye-spots" terrify foes by their resemblance to snakes. More ambitious in the same direction is the speculation that markings on the side of the inflated head of a lantern-fly suggest an alligator and thus frighten the insect's enemies. The first of these guesses ignores the universal phenomenon that evidences of attack stimulate further aggression. Disabled creatures are fair game for predators, even of types that would not attack them in sound condition. The fate of the wounded member of a pack or of the obviously pecked bird in a flock are familiar proofs that wounds are a liability. The snake- and alligator-resemblance fantasies must be relegated to the sphere of pure invention, because the ordinary natural enemies of creatures so small as the insects concerned can have no impressions as to the appearance and powers of snakes and alligators. All the illustrations cited lean heavily on traits of animal psychology that are assumed, not known, to exist. They are imaginings and, if naïveté, are of an artificial sort scarcely creditable to their inventors.

There is unfeigned naïveté, however, and in the same field it produces speculations, which, though parallel to those cited, can be recognized as far-fetched even by persons who have given no special thought to adaptation hypotheses. For the present purpose such speculations are exemplified by quotations from the Journal of the New England writer, Henry D. Thoreau. This is done with no intent of holding Thoreau up to scorn, for he is admired for his contempt for worldly possessions, his love of nature and his poetic views on natural phenomena. It is of interest that the suggestions here quoted and numerous others in his Journal considerably antedate those of Belt, Wallace and Darwin—authors usually regarded as founders of the protective adaptation school.

Some of the examples attribute protection to harmonization with comparatively recent man-made environment—something that could not have been produced adaptively, that is, as a result of age-long natural selection.

BITTERN

I took out my glass to look for ducks, and my companion, seeing what I had, and asking if it was not a stake-driver, I suffered my glass at last to rest on it, and I was much surprised to find that it was a stake-driver after all. The bird stood in shallow water near a tussock, perfectly still, with its long bill pointed upwards in the same direction with its body and neck, so as perfectly to resemble a stake aslant. If the bill had made an angle with the neck it would have been betrayed at once. Its resource evidently was to rely on its form and color and immobility solely for its concealment. This was its instinct, whether it implies any conscious artifice or not. I watched it for fifteen minutes, and at length it relaxed its muscles and changed its attitude, and I observed a slight motion; and soon after, when I moved toward it, it flew. It resembled more a piece of a rail than anything else—more than anything that would have been seen here before

the white man came. It is a question whether the bird consciously cooperates in each instance with its Maker, who contrived this concealment. I can never believe that this resemblance is a mere coincidence, not designed to answer this very end—which it does answer so perfectly and usefully (pp. 69–70). [The resemblance is to a stake or a piece of rail.]

Vesper Sparrow

He sits on some gray perch like himself, on a stake, perchance, in the midst of the field, and you can hardly see him against the ploughed ground (p. 288).

Tree Sparrow

These birds, though they have bright brown and buff backs, hop about amid the little inequalities of the pasture almost unnoticed, such is their color and so humble are they (p. 297). [Resemblances to a stake, ploughed ground and pasture.]

Another set of excerpts attributes protection to sounds like those of the environment—a step further than most of the present-day adaptationists have gone.

American Merganser

Now and then they seemed to see or hear or smell us, and uttered a low note of alarm, something like the note of a tree-toad, but very faint, or perhaps a little more wiry and like that of pigeons, but the sleepers hardly lifted their heads for it. How fit that this note of alarm should be made to resemble the croaking of a frog and so not betray them to the gunners! (p. 25.)

Bittern

After the warm weather has come, both morning and evening you hear the bittern pumping in the fens. It does not sound loud near at hand, and it is remarkable that it should be heard so far. Perhaps it is pitched on a favorable key. It is not a call to its mate? Methinks that in the resemblance of this note to rural sounds, to sounds made by farmers, the protection, the security, of the bird is designed (pp. 65–66). [Farm environment is too recent to have any effect by "selection."]

Passenger Pigeon

I scare pigeons from Hubbard's oaks beyond. How like the creaking of trees the slight sounds they make! Thus they are concealed. Not only their *prating* or *quivet* is like a sharp creak, but I heard a sound from them like a dull grating or cracking of bough on bough (pp. 113–114). [Authors in general refer to overwhelming conspicuousness of passenger pigeons.]

Such speculations are best termed poetic fancies, but they are not more out of touch with reality than many of the protective adaptation effusions of much more recent authors. As to Thoreau, it was said:

He never became in any respect an expert ornithologist, and some of the reasons are not far to seek. He was too intent on becoming an expert analogist, for one thing. It better suited his genius to trace some analogy between the soaring hawk and his own thoughts than to make a scientific study of the bird.[1]

[1] Henry D. Thoreau, "Notes on New England Birds." Excerpts from his journal, arranged and edited by Francis H. Allen, 452 pp., 8 pls., 1 map, 1910.

An analogist, not an analyst was he, but it may be said that his naïveté was unfeigned and unavoidable, while that of modern marvellers, conscious of the just criticism of their course, is neither. Unique wonders here and there (as the leaf fishes, the shadowed toad, the shadowless grasshopper, etc., of 1938) are publicized without admission that living in the same environments with them and getting along just as well are other creatures that are not similarly "protected." The "adaptations" are thereby shown to be unnecessary to survival in that environment, hence they can not have been produced as postulated by the natural selection theory.

The elaborately adapted are advanced specialists. Like human specialists, who have been defined as those who progressively learn more and more about less and less, these excessively specialized creatures are more and more "adapted" to a less and less prevalent moiety of the environment. The more extremely they are specialized, the more restricted is the

fraction of the highly varied environment in which they can live. Thus they can not be increasing in numbers, hence do not answer to the criterion of a successful species under natural selection theory. They are following the course of all highly specialized creatures, that is, to senescence and extinction. The process, like all evolution, is orthogenetic and natural selection has nothing to do with it. Natural selection by definition is survival of the fittest, but beneficiaries of a process of survival of the fittest could not become extinct. It is stultification to assert that the mainspring of evolution as it evidently occurred is survival of the fittest.

In every geological age, the habitable world has been occupied by animals in variety. They were fit in their time, they were adapted, just as much as those of to-day, but they are gone. Among them may be instanced forms undoubtedly superior in their way to anything that exists to-day, as the great aquatic and terrestrial predacious birds (*Hesperornis, Diatryma*), the predacious dinosaur (*Tyrannosaurus*) that animated battering ram, *Triceratops,* the marine *Plesiosaurus,* the imperial elephant, giant bisons and elks, cockroaches and dragonflies, the saber-toothed tigers, and so on. In their lines these animals have never been surpassed; they did not perish from competition.

There have been wonders both great and small in every age, and to hail creatures of to-day as the fittest for their particular types of environment shows lamentable lack of perspective. As a rule, indeed, it seems that the great are gone, and only mediocrities remain. What would the adaptationists have done in an earlier age? Judging from their present behavior, they would have exploded with enthusiasm. In that fortunate event, we should not have to worry about them now, but it is only a dream from which we awake to realize that they are here and in some instances very active.

Naïvely they dote on marvels and the adulation they extend entitles the wonders to be known as "omeomys" and their idolaters as the "ohmy" school. It is somewhat surprising that this school flourishes most in a race that particularly prides itself upon poise. Perhaps the indulgence may be psychoanalyzed as a welcome release from that pose—a relaxation made respectable by association with a few big names.

SCIENCE AND THE "FOUNDING FATHERS"

By Professor JOHN WM. OLIVER
UNIVERSITY OF PITTSBURGH

THIS year, 1939, marks the sesqui-centennial of the establishment of our Federal Government. Once again, it will be appropriate for all those who want to call upon President Washington, or the members of his cabinet, or those who sat in those first sessions of Congress, for support in proving any one of a dozen pet theories that are abroad in the land. Such phrases as "from the very foundation of our government"; "The Founding Fathers stood for . . ."; "Washington and his colleagues demanded . . ."; "in the beginning our government insisted that . . ."; and others of similar note will be drummed upon until one wearies in hearing them.

But is it worth while for those interested in science to turn their attention back to the days of the "Founding Fathers"? Did they know or care enough about science to be concerned with it? Were they interested only in the political set-up of a new government? Let us see. A review of those first years reveals a surprising amount of interest on the part of the "Founding Fathers" in science, invention and technology.

President Washington, in his first Annual Address to Congress, delivered on January 8, 1790, emphasized, above everything else, the encouragement of agriculture, commerce and manufacturing by all proper means. He went on to say:

> I cannot forbear intimating to you the expediency of giving effectual encouragement to the introduction of new and useful inventions from abroad, and to the exertions of skill and genius in producing them at home. . . . Nor am I less persuaded that there is nothing which can better deserve your patronage than the promotion of science. . . .[1]

Both the House and Senate received the President's message most cordially. Within a few days they sent a favorable reply, declaring that "the introduction of new and useful inventions from abroad, and the exertion of skill and genius in producing them at home . . . shall receive such early attention as their respective importance requires."[2]

When Washington called upon the first Congress of the United States, and urged its members to encourage agriculture and all new inventions; and to promote science, he was expressing a hope that was already widely current throughout the young republic.

The period following the close of the Revolutionary War down to the establishment of the Federal Government is an important one in the early history of applied science and technology. During the years of the war, commerce had been interrupted, and the colonies had been cut off from the rest of the world. The American people had to depend upon themselves. This was true not only of war supplies, but also for the necessary articles needed in daily use. As a result, individual states had given all possible encouragement to their citizens during the war and the years immediately following. In 1783, Massachusetts built a glass factory with the proceeds of £3,000 of lottery money. In 1785 the South Carolina Agricultural Society offered medals for the making of oil from cotton, peanuts, sunflowers, sesame and other seeds. The same year, 1785 saw the birth of the Philadelphia Society for the Promotion of Agriculture, and a similar society in Massachusetts. In 1787, the manufacture of glass had been started in Massachusetts, New York and New Jersey. And in this

[1] Richardson's "Messages and Papers of the Presidents," I, 58.

[2] *Annals of Congress*, I, 934.

same year, the Pennsylvania Society for the Encouragement of Manufactures was organized. Before the decade of the 1790's had closed, salt was being successfully manufactured in western New York, morocco and colored leathers were being made in Philadelphia; Paul Revere had established an iron foundry, and John Hewson was printing calico and linen in Pennsylvania. In 1789, a French observer had noted that the farmer and artisan in America had more work to do than they could get done. The scarcity of labor made for high wages, and to supply the want of labor and time, the early Americans were forced to invent—to think out new ways of augmenting their efficiency.

First Patent Law

Washington's plea to Congress, asking for their support in encouraging the introduction of new and useful inventions and to lend their patronage to the promotion of science, was favorably received. A simple, workable patent law was one of the first needs. Soon after Washington's inauguration in April, 1789, Congress took up the question of establishing a new patent system. The debates continued, irregularly for almost a year. Early in 1790, Colonel John Stevens presented a petition to Congress that served as the basis of the new patent law. In April of that year, the act was passed and signed by President Washington. The law was short, simple and easily administered. Anything could be patented if it could be classified as "any useful art, manufacture, engine, machine, or device, or any improvement therein not before known."[3]

It was fortunate that Thomas Jefferson, Secretary of State in Washington's cabinet, was the man charged with the responsibility of administering the first patent law. Any project of a scientific, technical nature appealed to him. Jefferson possessed a most versatile mind. He was the best-suited man in this country for the new job. His enthusiasm for science and industry was not equalled by any other person of his day. He never overlooked an opportunity to promote a scientific inquiry or to add a new fact to his storehouse of technical knowledge. He was constantly encouraging the introduction of new devices and the application of science to everyday living. He had written in one of his numerous letters, "I have wished to see chemistry applied to domestic objects, to malting, to brewing, making cider, bread, butter, cheese, soap, and the incubation of eggs." He had already designed a new moldboard for a plow, scientifically constructed according to mathematical principles.

Jefferson had a profound faith in the inventive ability of his fellow Americans. He was sure that they were the equal in skill, ingenuity and inventiveness of any European. In 1785, he had been asked by an American father to advise him whether Rome or Geneva offered the best educational opportunities for his son. Jefferson's reply sounds almost like a rebuke. He wrote, "But why send an American youth to Europe for an education? What are the objects of a useful American education?" He went on to point out that emphasis in "our day" should be placed on agriculture, chemistry, botany—subjects that would be useful to an American.[4]

The inventive geniuses of the young republic were quick to take advantage of the new patent law. Upwards of fifty patents were issued under the act of 1790. New mechanical devices came so fast that the department of state was swamped with applications. Jefferson insisted on examining personally every application

[3] *Journal of The Patent Society*, Centennial Number, July, 1936, Vol. XVIII, No. 7, p. 63.

[4] "Jefferson's Writings," Memorial Edition V, 186.

that was filed. The work became so heavy that not only Jefferson, but other department heads found it impossible to hear and examine all applications. Accordingly, the act of 1790 was repeated, and a second act passed in 1793.[5] This act provided for the granting of patents in routine fashion, to any one who took an oath testifying to the originality of his device and paid the sum of thirty dollars. No one but a citizen of the United States could receive a patent. This act remained in force until 1836, when the Patent Office was reorganized with a rigorous system for the examination of all claims, in order to prevent duplication.

From the very beginning of our Federal Government, the protection of property rights of inventors has been a definite American policy. In Europe, invention privileges had been granted by the rulers. Over there, the privileges emanated from and were bestowed by the Crown. In America, however, the theory was defended that invention was a right, not a privilege. And the founders of the government proclaimed the patent laws as the agent by which they enjoyed those rights. The policy of this country from the very beginning has been to encourage useful arts. This policy has been a powerful factor in bringing about the innumerable inventions that have contributed to the greatness of American science and industry and to the comfort of the American people.

Hamilton's Report

That first American Congress, sitting in New York, devoted much time and attention to encouraging useful arts and infant industries. They were not unmindful of the part that American manufactures had played during the Revolutionary days. On January 15, 1790, the House of Representatives called upon Alexander Hamilton, Secretary of the Treasury, to prepare a "Report" on the subject of manufacturing. They asked particularly for suggestions looking toward the promotion of those industries that would render the United States independent of foreign nations.[6] Hamilton submitted his "Report" late in the year 1791.[7] It has rightly been called one of the great documents of early American history.

Hamilton surveyed the current status of the manufacturing conditions, and proposed means whereby they could be aided by proper encouragement. The developments of new industries and manufacturing would, he said, promote the division of labor, the use of machinery and stimulate new inventions. All this would furnish work for the unemployed. Increased employment would insure a steady demand for the surplus products of the soil; and animals, plants and minerals would acquire a utility which they had not heretofore possessed. Hamilton proposed to encourage these new industries by setting up a protective tariff. But even more important was his proposal to encourage new inventions and new discoveries here at home. His "Report" was given the widest possible publicity. One immediate result was that the individual states got busy and awarded special bounties for new industries and granted special tax exemptions to others. Prizes were offered by numerous societies that had been formed to stimulate domestic production.

Origin of Manifest Destiny

The founders of the young republic were keenly alive to the economic and scientific possibilities in this New World. Jedediah Morse's book, "American Geography," which had just been printed (1789), was bristling with the idea of manifest destiny for this stirring young

[5] *Annals*, Appendix, III, 1431.

[6] *Annals*, I, 1058.

[7] *Annals*, III, Appendix, 971–1034.

nation. One section of that epochal little volume was devoted to the Western Country—the trans-Allegheny region. He described the seat of empire as ever traveling from east to west. The last and broadest seat of that empire would, in his opinion, be in America. Here the conditions were suitable for the highest degree of the sciences and arts. He declared that in the United States, genius, "aided by all the improvements of former ages, is to be exerted in humanizing mankind—in expanding and enriching their minds . . . with philosophical knowledge."[8]

The most philosophical as well as the most practical scientist of this period was, of course, Benjamin Franklin. True, he died (1790) just as the new government was being established, but during his long life he had advanced the cause of science, practical and theoretical, more than any other person in American history. His work in physics, meteorology, mathematics, geology, chemistry, medicine and natural history places him among the great men of science for all time. As he was approaching the end of his life, he declared in a letter to Priestley that his chief regret was that he had been born too soon. He sensed a great scientific future for young America. The time would come, he prophesied, when a rigid system of sanitation would be enforced. Scientific farming would be introduced, and with the use of preventive medicines, man's span of life would be lengthened at pleasure, even beyond the ante-diluvian standard.[9]

Morse, Franklin and the "Founding Fathers" had good reason for feeling so confident of America's scientific future. Already, a number of small, but promising industrial and manufacturing developments were well under way. When the new Ship of State was launched in 1789–90, there were paper mills, glass plants, potteries, iron foundries and forges already in operation. The mineral resources of the young nation were yet unknown. Iron ore was abundant for the then simple needs. Some coal, copper, lead, gold, silver and sulfur had been extracted. Fisheries and shipyards were sources of great wealth. James Wodehouse and his scientific friends were busy organizing the first Chemical Society in the United States in 1792. One of its objects was to acquaint the public with the various uses of minerals and to encourage the manufacture of pottery.[10]

This same year 1792, a professorship in natural history, chemistry and agriculture was established at Columbia University, at an annual salary of 200 pounds. Two years later, 1794, the famous Dr. Joseph Priestley arrived in this country, and lent his aid to the enthusiastic young scientists of America. David Rittenhouse, whom Jefferson declared to be "the greatest mechanical genius of the world," was rewarded by our first President in being appointed the first Director of the Mint. By 1792, Mathew Carey's book, "American Museum" had, due to its popularity in promoting home industries, run through twelve editions. During this same period, Tench Coxe was writing to James Madison, a member of Congress, urging that an appropriation of a million acres of western land be set aside to provide funds to reward the introduction of machinery, invention, art and other projects of similar nature.

The "Founding Fathers" during those first years when laying the structure of a new government were equally concerned in pointing the way that applied science,

[8] J. C. Parish, "The Emergence of Manifest Destiny," p. 16. Los Angeles, 1932.

[9] N. G. Goodman, "The Ingenious Doctor Franklin," 11, 12. 1931.

[10] In 1795, Wodehouse became professor of chemistry in the University of Pennsylvania; two years later he published the "Young Chemists Pocket Companion," the first chemistry laboratory guide to be published in the United States.

inventions and industrial progress should develop. Now that political independence had been won, they were equally anxious to establish economic independence. They reflected the universal optimism of that day, which told of the unlimited possibilities that lay ahead for all who were willing to take a chance. Washington, Jefferson, Hamilton, Franklin, Coxe and others believed strongly in harnessing the forces of nature to the chariot of human progress by means of applied science and technology. Over and over again, one reads statements like these, sprinkled among the weighty political discussions: "the prosperity of the United States is the primary object of our deliberations"; "manufactures and useful inventions are our first needs"; "I, (Washington) cannot forbear intimating to you the expediency of giving . . . encouragement to the introduction of new and useful inventions, . . . and to the exertion of skill and genius in producing them. . . ." And in addressing his fourth Congress, Washington reviewed the great progress made in agriculture, commerce and manufacturing, declaring," with resources fully adequate to our present exigencies . . . with government founded upon the general principle of national liberty, with mild and wholesome laws—is it too much to say that our country exhibits a spectacle of national happiness never surpassed, if ever before equalled?"[11]

Such words sound like a scientific benediction from the Father of Our Country! Here was a young nation whose people had for a century and a half been trained to provide their own needs, and to supply their own wants. Now, with those "mild and wholesome laws" which President Washington promised as an incentive to go forward, the next century and a half was to witness an advance in the field of science and technology, the like of which the world had never seen.

[11] Richardson's "Messages and Papers of the Presidents," I, 176.

THE WHALE SHARK IN THE CARIBBEAN SEA AND THE GULF OF MEXICO

By Dr. E. W. GUDGER
BIBLIOGRAPHER, THE AMERICAN MUSEUM OF NATURAL HISTORY

IN a comprehensive paper[1] covering twenty-two years' work on the geographical distribution of the whale shark, I have located every known specimen as of December 31, 1934. In this article may be found the scanty data for the Caribbean—and all at second and third hand. While for the Gulf, excepting second- and third-hand reports of the occurrence of *Rhineodon* in the Yucatan Channel, and numerous records (made mainly by myself) of its occurrence in the Strait of Florida (Florida coast and off Havana), all was blank. Even lacking scientific evidence, one could still be sure that this great fish was found in the Caribbean and Gulf; for its relative abundance in the Strait of Florida, explainable only on the basis of the manner of distribution, showed that it must be found in the Caribbean and the Gulf. But what was necessary was direct evidence. This I now have. It will be set out in chronological order.

RHINEODON IN THE CARIBBEAN SEA

Report No. I.—In 1937, I published a short note[2] on a whale shark impaled on the bow of a steamer on the run from Cristobal, C. Z., to Cartagena, Colombia. This report was made possible through the kindness of Chief Officer A. E. Richards of the vessel concerned, who came to my office in the Museum and described the shark and its capture.

No. II.—For information as to another occurrence of *Rhineodon* in Caribbean waters, I have to thank Mr. Fred Fletcher, a newspaper man, who sent me a clipping describing the curious behavior of a great shark around the steamer *Colombia* of the Colombian Steamship Company in the harbor of St. Marc, Haiti, March 24, 1937. My letter to the company asking for information came to the attention of Mr. C. H. C. Pearsall (president of the steamship company) who fortunately was on the steamer at the time and who has kindly given me full details.

The great shark hung around the steamer in the early evening while she was loading bananas under strong electric lights. A number of the crew got out firearms and shot at it, but from its 3- or 4-inch thick armor-like skin the bullets glanced harmlessly. Boys in small boats were alarmed by the familiarity of the shark and hurried aboard ship, letting their skiffs drift away. The fish came up under the companionway one time, raised its head and dislodged the platform at the bottom of the ladder. Occasionally it bumped into the ship, the impact being readily noticeable. It stayed around the ship about two hours, but would not take baited hooks (no harpoon was available). It being night, no photograph could be made.

I asked Mr. Pearsall if this could be a large tiger shark. He said that he knows the tiger and that it was not, and gave me a description of this shark (estimated to be about 25 feet long), which showed conclusively that the fish that played around the ship was a *Rhineodon*. Later when I sent him a copy of my article[3] on the whale shark captured off Long Island in 1935, which fortunately he had seen at Islip, Mr. Pearsall unhesitatingly identified the St. Marc fish as identical with the Islip specimen.

[1] *Proc. Zool. Soc. London* (for 1934), 1935, pt. 4, 863–893, pl.

[2] *Copeia*, April 10, 1937.

[3] *Nat. Hist.*, 37: 159–166, 7 figs., 1936.

Here then are two proofs of the occurrence of the whale shark in the Caribbean. This lends credence to the second- and third-hand accounts previously adduced.

SHARKS IN THE GULF OF MEXICO

The eight accounts now to be quoted have all come to me through the courtesy of the U. S. Hydrographic Office. They are the responses to a brief article (with a figure of the fish) published in the *Hydrographic Bulletin* in 1934, and to the later publication therein of various notes on reports by ships' officers of whale sharks seen in various regions. It is a pleasure to make acknowledgment of the generous help of the Hydrographic Office for these and other data.

Reports Nos. I and II.—Mr. S. H. Reid, chief officer of the S.S. *Dungannon,* of the Texas Company, reports that on August 10, 1933, while on a trip from New York to Port Arthur, Texas, in Lat. 28° 00′ N. and Long. 90° 20′ W., the ship passed close to a school of 6 large sharks moving slowly about. Five days later (August 15) on the return voyage from Port Arthur about 2 P.M., the ship being approximately in the same position, Mr. Reid saw what was apparently the same school of 6 specimens. They were entirely unafraid, indeed one left the school and came alongside the ship and then went back to the group.

Mr. Reid's description is so definite as to tail, shape of head, coloration, etc., that it assures me that these were whale sharks. He estimates their lengths at 40 to 50 feet. They are the only ones he has ever seen or known of in the Gulf of Mexico.

No. III.—Mr. E. Kvande, second officer of the S.S. *Gulfoil* of the Gulf Refining Company, reports that about 2 P.M. on May 14, 1935, his ship passed a school of great sharks in Lat. 27° 31′ N., and Long. 89° 47′ W., on a voyage from Port Arthur to Philadelphia. The day was clear and the sea relatively quiet. The fish appeared close on the port bow, and the nearest had to steer off to clear the ship, passing leisurely at a distance of about 40 feet. Twelve were counted, swimming near the surface, each with back fin and upper part of tail above water. The two nearest were estimated to be 25 to 30 feet long. Two solitary fish led the school, eight swam in fairly defined pairs, and two stragglers brought up the rear. Mr. Kvande correctly reports the shape of the head, white spots on head, fins and tail, and the checkerboard squares with white spots.

No. IV.—This occurrence is reported by Captain Aug. Randall, of the S.S. *John D. Archbold,* of the Standard Oil Company of New Jersey, as noted on May 24, 1937, in Lat. 26° 02′ N., and Long. 88° 21′ W. The school was seen at 11:45 A.M. and was estimated to be made up of about 30 fish. They were not disturbed by the ship's passing them at a distance (to the nearest) of about 20 feet but swam lazily along and "did not appear to be going anywhere." The sky was clear and the sea smooth and the fish were readily observed. Captain Randall's description of the make-up and coloration of the sharks leaves no doubt that they were whale sharks. They appeared to be about 14 feet long, and hence were young and immature specimens. Their small size leads to the conclusion that the whale shark breeds in the Gulf of Mexico.

No. V.—Mr. V. D. Parsons, second officer of the S.S. *Albert E. Watts,* writes that on May 26, 1937, at 4 P.M., his vessel passed 6 whale sharks in Lat. 26° 48′ N., and Long. 88° 35′ W. These seen at a distance were thought to be whales or blackfish, but, when approached more closely, were seen to be neither. The position and shape of the mouth, the fins and the coloration (checkerboard, etc.) corresponded with the figure of *Rhineodon* in the *Bulletin.* The fish were not afraid, though the vessel passed so closely that her wash broke over them. Mr. Par-

sons reports that had the nearest one been in the ship's path, it would have been rammed, so sluggish was its motion. The fish were about 30 feet long.

Nos. VI and VII.—Both these accounts are reported by Captain Edw. J. Niblett, of the British S.S. *Eskdene*. The sharks were seen on different trips in 1937.

On a voyage from the River Plate to Houston, Texas, in May, 1937, the ship passed quite close to four of these fish in Lat. 27° 10′ N. and Long. 89° 50′ W. They were in pairs about 40 feet apart, of unequal size—the largest being 25 to 30 feet long. They too were so sluggish that they made no attempt to get away from the steamer. The checkerboard markings were distinct on all and corresponded with those shown in the *Bulletin* article.

On her next voyage (from Corner Brook, N. F., to Beaumont, Texas) on July 17, 1937, in Lat. 27° 20′ N. and Long. 89° 40′ W. (in almost the same position as before) Chief Officer G. Stronghair noticed a great shark, identical with those seen before and with the figure in the *Bulletin*.

No. VIII.—Last of all, Officer H. S. Brewster, of the Gulf Oil S.S. *Gulfbelle* reports that on May 9, 1938, at 10:00 A.M., his vessel sighted three whale sharks in Lat. 26° 15′ N. and Long. 81° 58′ W. They were close to the ship, swimming just awash slowly in a southerly direction. These fish were about eighteen or twenty feet long and had wide heads. Their color was black with round white spots. They were surely whale sharks.

Data from the Gulf of Mexico

The reader has noted that the observations were made on trips to or from the eastern Texas oil ports. And to bring more sharply and clearly the matters set out above, the data are synopsized in Table I.

From the table the reader finds that eight observations are recorded from six ships, two each from two different ships—the two observations from the *Dungannon* in the same locality. The dates run from May 8 to August 15, and the years are 1933, '35, '37, '38. The fishes counted are 38 and those estimated are 30—a total of 68. Surely it may be said that at least 50 whale sharks were seen in the Gulf of Mexico from which not a single specimen has ever been recorded before. Last of all and most notable is the close contiguity of the places in which these great sharks were seen. This deserves special attention.

It is significant that these reports come from (oil?) ships plying to and from east Texas oil ports through the Strait of Florida to or from the eastern ports of North America. The one exception is the *Eskdene* from the River Plate to Houston. She must surely have come through the Caribbean. The latitudes and longitudes have been plotted on Chart I that it may be seen how close to each other these positions are.

These localities are strung out in a northwest-southeast direction over a distance of approximately 175 miles. Their east and west spread is approximately 120 miles. Finding a center, they are all

TABLE I

Rept. No.	Steamer	Date	Voyage	No. of sharks	North Latitude	West Longitude
I	*Dungannon*	Aug. 10, '33	to Port Arthur	6	28° 00′	90° 20′
II	*Dungannon*	Aug. 15, '33	from Pt. Arthur	6	28° 00′	90° 20′
III	*Gulfoil*	May 14, '35	from Pt. Arthur	12	27° 31′	89° 47′
IV	*Archbold*	May 24, '37	....	c. 30	26° 02′	88° 21′
V	*Watts*	May 26, '37	....	6	26° 48′	88° 35′
VI	*Eskdene*	May —, '37	to Houston	4	27° 10′	89° 50′
VII	*Eskdene*	July 17, '37	to Beaumont	1	27° 20′	89° 40′
VIII	*Gulfbelle*	May 8. '38	....	3	26° 15′	86° 58′

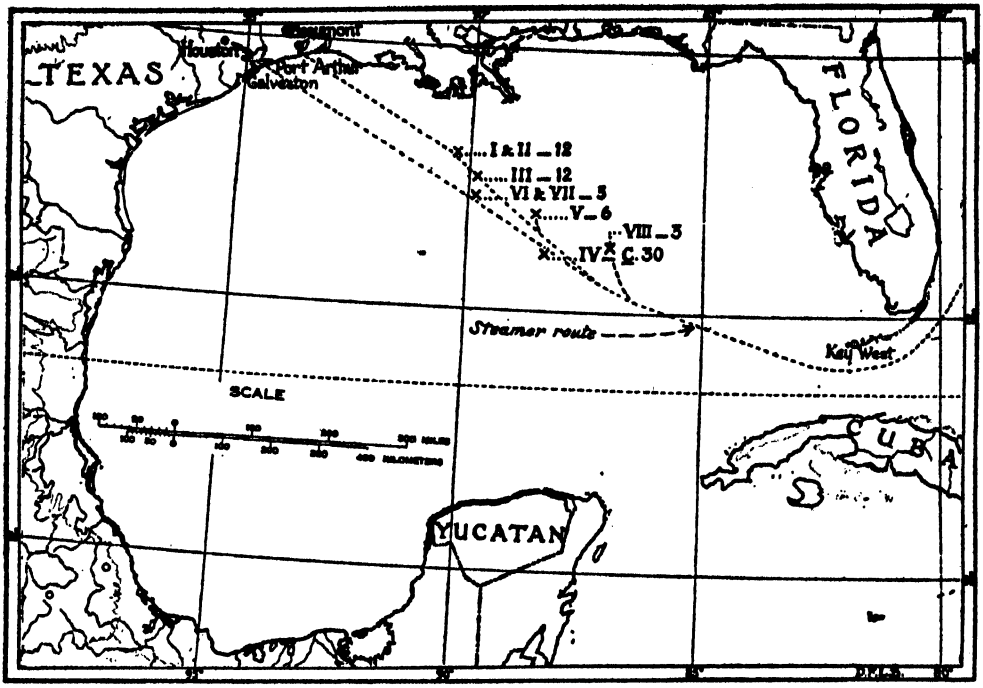


CHART I. CHART SHOWING THE LOCALITIES OF EIGHT GROUPS OF WHALE SHARKS OBSERVED IN THE GULF OF MEXICO

THE LOCALITIES ARE MARKED THUS—X. THE ROMAN NUMERALS INDICATE THE REPORTS OF OBSERVATIONS IN CHRONOLOGICAL ORDER, THOSE IN ARABIC THE NUMBER OF WHALE SHARKS SEEN FROM EACH VESSEL. THE DOTTED LINES SHOW THE STEAMER ROUTES, WHICH CONVERGE INTO ONE.

contained in a circle whose radius is 87.5 miles. Or they are all contained in a parallelogram whose height is *c.* 175 miles and whose base is *c.* 120 miles.

This is very difficult. So far as I can find there is no peculiarity of currents which might account for the gathering of whale sharks here. I have always held that *Rhineodon* was a littoral shark. In the extensive article above referred to, the 76 individuals listed had all been found at least fairly close along shore. But in the chart the nearest group was about 70 miles from land and in water 200 fathoms deep. The farthest group, No. IV, was 200 miles from the nearest land (the delta of the Mississippi River), and in water 1,250 fathoms deep.

As reported, these fishes "did not seem to be going anywhere," they were not "making a passage" but were just loafing along. Their concentration may have been due to a concentration of their food, which seems to be small fishes, squids, jellyfishes, small crustacea—probably all kinds of plankton. If this is so, it merely pushes the question back so much further.—What causes the concentration of the sharks' food in this particular region? And to this no answer can be made in the present state of our knowledge.

The things we can be sure of are that these fish were on the dates specified in the track of steamers between the eastern seaports of Texas and the Strait of Florida, and that they came under the eyes of ships' officers whose vigilance had been stimulated by the publication of the little article and of various records of occurrences of the shark in the *Hydrographic Bulletin,* and lastly that they showed no fear of the vessels and were swimming slowly along in no particular direction.

THE ORIGIN OF BIRDS

AND WHICH CAME FIRST, THE BIRD OR THE EGG?

By Dr. EDWARD L. TROXELL

PROFESSOR OF GEOLOGY, TRINITY COLLEGE, CONNECTICUT

THE age-old question—Which came first, the bird or the egg?—seems now to have an answer, thanks to studies in genetics and in evolution, and, any way you look at it, the egg wins.

Of course there are many who believe that adult birds were created *de novo;* like Adam, they were fashioned out of dust and flew away without parent or pedigree. To the scientist this belief offers no food for thought, so let us confine our inquiry to an orthodox scientific basis and see what answer comes to the problem, Egg or bird?, first.

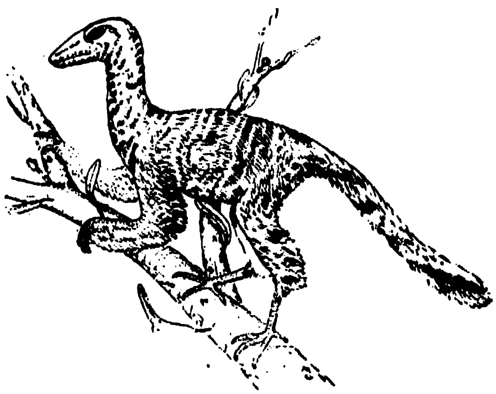
In a study of this problem, which deals so intimately with bird-ancestry, it is inevitable that one be concerned with the origin of feathers, of flight and of other such things that seem to be so essentially a part of bird make-up.

The story of bird origin actually begins far back in geological time, but for the present purpose we shall take it up at the close of the Great Coal Period, where we see just the right climatic conditions for the beginning of the feathered folk. From many and varied evidences the geologists are aware of vast changes in the physical conditions at that time; there was increasing aridity and coldness; it was a time of mountain-making and upheaval. In the circumstance nature, it would seem, set out to devise a type of animal that could withstand the new conditions. This new creature was to be a "reptile" that would be covered with a coat of downy feathers; it would stand up on its hind legs, lift its body up off the cold ground, would have greater activity and would maintain a constant body temperature. When this was accomplished, especially when a coat of feathers was formed, the bird was created. Indeed, the moment one mentions a "reptile" with a coat of feathers one has already described a bird. It is notable that, in the last analysis, feathers, alone, are the distinctive feature of the birds; not egg-laying, for reptiles and some mammals share that with the birds; not flying, for both reptiles and mammals have learned to fly.

It is a well-established fact that birds evolved from a race of reptile-like animals which, themselves, had had a long period of evolution. Through hundreds of thousands of years, doubtless, there went on a gradual change from the scaly ancestor to the feathered bird. It would have been difficult to tell, even if one had been there, just when the change was completed; it would have been impossible to mark the point where the transition was completed in this marvelous formation of the bird, although, in theory, there was some definite point, some stage in the race history where the parent was reptilian and the next generation was avian. But it is not necessary, in making our point, for us to know at exactly what time or at what generation of bird ancestry the jump from one type to the other came. Assume that as you wish; the significant thing is this: *when the change did come it came between the adult of one race and the egg of the next.*

The first bird grew from a germ, an egg, that had the qualities of a bird—hence was a bird. One must not lose track of the fact that the egg is the animal, even though immature, that the adult may be considered as something added to the earlier stage.

Now let us make use of the definitely accepted principle in heredity and variation that, briefly stated, is: New characters arising in the course of evolution come at the time of conception, at the time when the two elements from the parents combine. Therefore, the new features that distinguish the first bird originated from parents that did not possess them, that were reptiles. It is possible that some one may argue that the descendant, the offspring, of a reptile must be a reptile also; that depends entirely upon our definitions. With that in mind we must give up the word "reptile," which no longer serves the purpose; it is a term lacking in precision for the broad group within which the transition took place from reptile to bird.



THE HYPOTHETICAL FIRST BIRD
SOFT FEATHERS THAT FIRST SERVED FOR WARMTH BECAME LONGER ON THE BACK, LEGS AND TAIL, OUT-OF-THE-WAY PLACES. STIFFENING THEY WERE LATER USED FOR FLIGHT.

To make the meaning clearer we may say that a child of human parents, today, may be so different that one is forced to give up the term "human" in an attempt to define it. The child may be a monster, removed from the normal human being by a considerable degree. In that sense the first bird was a "monster," a "sport," in the scientific use of the words; it was a new variation that went on to establish its kind for the ages to come. This is quite the usual thing in reproduction, and men set out with purpose and understanding to produce new species by noting and saving such abnormal characters as may appear in various races. Burbank had a distinguished career with plants; others have succeeded with animals of many sorts.

Extending our inquiry a step further back, it is just as important and interesting to know which came first, the reptile or its egg. Again, and in the same manner, the egg must come before the adult for here, as always, the transition between the amphibian, the ancestral form, and the reptile, the new species, came between the parent of the one race and the egg of the next. Similarly, the fishes in evolving into amphibians produced the necessary change that made a new type.

When we carry the line of descent back to the simplest primordial organism we are amazed to find that the law still holds; there the whole animal was nothing more than an egg, a single-celled form. Of course these never grew to adulthood, with legs and arms and all the other adult attributes; but that does not alter our notion; it rather confirms the thought that all animal life starts from an egg.

In any discussion of the origin of birds one comes to the consideration of the nature of the earliest birds, animals with feathers, and, since flight is so characteristic a feature of them, how they came to fly. One favored theory is that certain ancient reptiles, having a habit of running rapidly on their hind legs, learned to flap their arms, at first for balancing. It is supposed that the scales on the front limbs and tail increased in length and breadth, came to be frayed on the edges, grew lighter and eventually were feathers. These scale-feathers furnished the means of flying.

I like much better the idea that feath-

ers, even though they are merely modified scales, were developed at first for warmth, as a protection for lizard-like "reptiles" that lived in the inclement weather of Permian time. The mechanics of the process fits rather well the supposed conditions of the period: (1) a more active lizard pursuing its prey or getting away from danger, (2) rising off the cold ground, (3) running on its hind legs, (4) developing softer and fluffier scales, that (5) furnished some protection from the cold and, (6) in turn contributed to greater activity. Just when warm blood came to be a part of the equipment of the birds no one can state, but it had an immediate advantage when it did come, for it enabled the creature to continue its activities when the other "reptiles" were hibernating.

For a vast period of time such a type of bird would have carried on its existence much as the other animals of its group. But from generation to generation the feathery covering would vary; the feathers would be softer or more bristly, longer or thinner, etc. Where they were longer, by chance, there might be advantage or disadvantage; for instance, if longer feathers happened to grow on the after parts of the body, behind the limbs or on the tail, they would not greatly interfere with the animal's progress. Feathers that stuck out in any other direction would be a handicap and would be eliminated by nature.

Visualize it for yourself; a prehistoric bird, perched on a limb with its long streaming feathers extended by the wind it faced. Birds to-day perch facing the wind. Or imagine this same bird running, its feathers so constructed as to conform to a highly important stream-lining.

Now it is entirely within reason that those longer feathers, extending backward from the limbs for wings and from the body to form the tail, increased in stiffness and came to be the very instruments and means of flight. Flying, in our opinion, was not done by a cold, scaly reptile, but by a bird that was already equipped with a warm covering of feathers. It is interesting to note that, while many believe the first birds flew by use of their front limbs and tail, Dr. William Beebe conceives of a four-winged origin of flight; he has called this first bird *Tetrapteryx*. Here, too, the stiffened feathers project backward from the limbs and the tail. While it is a fact that the front limbs have superseded the others in the task of carrying the birds through the air, many birds to-day show extensive feather growth from the hind limbs as well.

Summary of the Origin of Birds

The ancestry of the bird goes away back through the reptiles, amphibians and fishes, and there it is lost in obscurity.

It is our opinion that certain reptiles developed a downy coating of modified scales for protection from cold and qualified as birds.

These fluffy feathers grew longer on the backs of the limbs and body and then, adapting themselves to a new purpose, made it possible for the birds to leap, to soar and eventually to fly.

We believe the egg came before the bird—answering an old, old question—because:

(1) No bird ever came otherwise than from an egg.

(2) An egg is a bird as truly as is the adult.

(3) New variations always arise with the egg's forming.

(4) All animal life has had its ultimate origin in a single-celled type—an egg.

Shortly after the Great Coal Period a scaly reptile laid an egg that had qualities not existing in the parent; that was the first bird.

FORTY YEARS OF MATHEMATICS

By Professor G. A. MILLER
DEPARTMENT OF MATHEMATICS, UNIVERSITY OF ILLINOIS

IT is always interesting to consider definite evidences of progress in a scientific subject, especially since the vast recent growth of the scientific literature makes it more and more difficult to evaluate the nature of various supposed advances. About forty years ago a standard work of reference began to appear under the title, "Encyklopädie der mathematischen Wissenschaften," which enlisted as never before the services of leading mathematicians of various countries. The number who finally had shared in the preparation of this work exceeded two hundred, and it seems reasonable to assume that the various parts thereof represented at the time of their appearance about the best knowledge along their lines that was then available. The first article thereof relates to arithmetic and appeared in 1898. In view of the elementary character of this subject it is unusually easy to understand its shortcomings, especially with respect to its historical references, to which the present article is explicitly restricted.

Note 18 on page 12 of Volume 1 consists of eight sentences. Six of these involve assertions which are now commonly known to be incorrect. As this note relates to negative numbers and hence is within the comprehension of nearly all educated people it may be of sufficiently wide interest to consider here briefly the nature of some of these incorrect assertions which so recently were accepted by the mathematical élite. In the first sentence of this note it is asserted that in a logical development of arithmetic the introduction of the negative numbers must precede that of the fractions. The fact that this is not now commonly accepted is illustrated by the article on general arithmetic in the recent Italian "Enciclopedia delle Matematiche Elementari," where positive fractions are treated before the negative numbers. The latter are included therein among the "numeri relativi," page 167, while the former appear on page 143. In the third sentence of this note it is asserted that the first traces of negative numbers appear in the work of the Indian mathematician Bhaskara (born in 1114), who distinguished between the positive and the negative square roots. It is now well known that even the ancient Babylonians occasionally used negative numbers and that Indian mathematicians used such numbers more than five hundred years before the time of Bhaskara.

In the fourth sentence of the given note it is asserted that the Arabs recognized negative roots, while in the recent third edition of Volume 2 of J. Tropfke's "Geschichte der Elementar-Mathematik" it is explicity stated, on page 97, that it results from the text-book on algebra by Alkarhi (about 1010), and others, that the Arabs considered negative solutions as inadmissible. In the following sentence of this note the date of the "Ars Magna" of H. Cardan is given as 1550 instead of 1545, and in the next to the last sentence of this note it is asserted that Th. Harriot (1560–1621) was the first who used negative numbers by themselves and allowed them to appear separately as a member of an equation. On the contrary, O. Neugebauer recently pointed out that this credit belongs to the ancient Babylonians.[1] Finally, the last sentence of the

[1] "Mathematische Keilschrift Texte," part 3, page 38, 1937.

given note contains two misstatements in regard to the work of R. Descartes (1596–1650). The former of these asserts that the actual calculating with negative numbers begins with Descartes, while it is now well known that it is posterior to Descartes. It is also stated here that R. Descartes assigned sometimes a positive value and sometimes a negative value to the same letter, which is also now commonly known to be inexact.

The misstatements just noted naturally would be of much less general interest if they did not appear in a work which is still widely consulted by those who seek reliable information and which only forty years ago had the endorsement of some of the foremost mathematicians living at that time. Elementary mathematics is still too commonly regarded as a subject exhibiting comparatively little progress in recent times, and hence it is especially important to emphasize the fact that its history exhibits remarkable recent advances. Among the other evidences of these advances found in the given encyclopedia article we may cite that on page 5 of this article it is stated that the calculation with letters, with the employment of the symbols $=$, $>$, $<$ and the operational symbols, was first developed in the sixteenth century. It is now well known that the symbols $>$ and $<$ for greater than and less than were introduced by Harriot in the first half of the seventeenth century (1631) in his "Artis analyticae praxis," and that some of the now common operational symbols of arithmetic, including the double sign $\pm$ and $\times$ for multiplication, were also introduced after the close of the sixteenth century. On the other hand, the ancient Greeks calculated already with letters which were assumed to represent general numbers.

On page 9 of the given encyclopedia article it is stated that Diophantus, who is commonly regarded as the most noted Greek algebraist, used the final sigma of the Greek alphabet to represent the unknown quantity. While this is in accord with the view commonly expressed forty years ago, the noted English historian of Greek mathematics, T. L. Heath, has since then given various reasons for assuming that this symbol is a contraction of the first two letters in the Greek word for number, and the latter view has since then been widely accepted as the more reasonable one, even if it is not possible to speak with perfect assurance about such matters. At any rate, the positive statement that the given symbol is the final sigma of the Greek alphabet can not now be regarded as an up-to-date statement relating to the symbol used by Diophantus to represent the unknown quantity in algebra.

On page 21 it is stated that J. Kepler (1571–1630) introduced the decimal comma, while it is now known that J. Napier (1550–1617) was the first to use this now very common symbol. A much more serious misstatement on this page is that the ancient Babylonian astronomers used fifty-nine different number symbols in their representation of the positive integers to the base 60 corresponding to our nine digits in representing the positive integers to the base 10. It seems quite remarkable that such a very unreasonable statement was commonly accepted as true forty years ago, since the use of fifty-nine different numerical symbols in the early stages of civilization is in disaccord with the slow development of the early numerical notations. The use of the sexagesimal system of numerical notation on the part of the ancient Babylonians still presents various unsolved questions, and many remarkable mathematical advances were made by them, but they employed only a small number of different numerical symbols, and only two of these were com-

monly used to represent the positive integers up to 60.

The preceding remarks relating to historical errors which were current forty years ago are here of interest primarily because they may serve as a background to explain the numerous errors which appear in various current text-books on the history of mathematics. The most influential of these was the "Vorlesungen über Geschichte der Mathematik," by M. Cantor, which began to appear in 1880 and was very favorably received, notwithstanding its numerous inaccuracies. In fact, the misstatements noted above were partly due to these inaccuracies. In 1888 W. W. R. Ball published the first edition of his "Short Account of the History of Mathematics," which involves a relatively larger number of inaccuracies but became very popular, and its later editions were translated into various other languages. In America the text-books by F. Cajori which were largely based on those just noted began to appear in 1893 and helped to transplant a large number of erroneous views in attractively written books. The later text-books by D. E. Smith did little towards correcting the inaccuracies which had been embodied in the most commonly used text-books on the history of mathematics.

The most effective work towards removing inaccuracies from the text-books on the history of elementary mathematics during the last forty years has been J. Tropfke's "Geschichte der Elementar-Mathematik," which began to appear in 1902. The first edition was published in two volumes, while the second edition appeared in seven small volumes from 1920 to 1924. In 1930 a third enlarged edition in seven volumes began to appear, but its publication has proceeded slowly. The third volume of this edition was published in 1937. By means of these revisions it was possible to take advantage of recent discoveries and to correct various mistakes in the earlier editions. In particular, the third volume of the third edition embodies many of the recent discoveries relating to the solution of the quadratic equation and devotes about 68 pages to this subject, while only 27 pages were devoted thereto in the preceding edition, which appeared only about 15 years earlier. There are few other subjects of elementary mathematics whose history has been more fundamentally extended during the last forty years than that of the quadratic equation, whose development can now be traced through about four thousand years.

The most original work on the history of mathematics which was published during the last forty years is the "Vorlesungen über Geschichte der Antiken Mathematischen Wissenschaften," by O. Neugebauer (1934), which is largely devoted to the mathematics of the ancient Babylonians and the ancient Egyptians, and may be regarded as the first effort to give a systematic exposition of pre-Grecian mathematics. In the preface to this volume it is stated that ancient mathematics consists primarily of two developments which are widely separated with respect to time. The more extensive of these two developments is due to Greeks and is exhibited among others in the works of Euclid, Archimedes and Apollonius, while the other is in the main more than a thousand years older and is largely due to the ancient Egyptians and the ancient Babylonians. Comparatively little is as yet known in regard to the influence of the latter on the former, since the ancient Greeks seldom gave references to the earlier work. In particular, the fundamental "Elements" of Euclid contain no historical references, but this may be more largely due to the difficulty of getting accurate historical information at that time than to a lack of generosity on the part of the ancient Greeks. Even at the present

time carefully selected historical references are seldom given.

The given volume by O. Neugebauer emphasizes the fact that the ancient Babylonian and Sumerian mathematics was largely algebraic. It included the partial solution of algebraic equations of different degrees, but those of the second degree are especially interesting, since some of the methods used here are general, but their significance was not fully understood until about four thousand years later when the number concept had been extended so as to include a clear theory of the negative and the complex numbers. One of the profoundest facts of ancient mathematics is that in the algebraic work it is always hampered by a lack of insight into the number concept, and it is important to note that this insight was not secured until about the beginning of the nineteenth century. Hence all the earlier algebraic work was bound to suffer as regards generality and elegance, especially with respect to the solution of algebraic equations. The partial solutions of such equations which we meet in the work of the ancients and in that of the middle ages naturally arouse our pity more than our admiration, even if elegant special devices are frequently met in the older developments.

The American student of the history of mathematics is naturally especially interested in the question of the reliability of the various sources of supposed information. While the rapid recent progress in this history is encouraging it also implies that greater care must be exercised by those who desire to avoid the spreading of mathematical myths which are still too common in our literature. Many of these have been so modified by various popular writers as to appeal strongly to the imagination of young students, and hence they have been eagerly adopted by writers of text-books. It is, however, reasonable to assume that they can not be as stimulating permanently as the truths which are reinforced continually by the addition to our knowledge and tend to explain new facts as they come within our enlarged vision. The interrelations between mathematical results naturally stand out clearer as our knowledge increases and tend to exhibit inconsistencies with popular errors. It might appear almost impossible that so many errors could appear in some of our popular histories of mathematics if one did not consider that only forty years ago such a standard work of reference as the "Encyklopädie der mathematischen Wissenschaften" embodied much which is now known to be untrue.

The deep interest in the history of mathematics on the part of the promoters of this large encyclopedia is attested by the fact that it was planned to include this subject in the final volume thereof, which plan unfortunately was later abandoned. Since many historical facts are unusually rich in their implications they may become fertile ferments in the minds of the thoughtful students, and hence teachers colleges have commonly included courses in the history of mathematics for those who prepare themselves to teach mathematics in the schools of our country. Much of the recent progress in this subject is not yet available in the English language nor in any other one language, but at the present time more of it appears in German than in any other one language. According to J. W. L. Glaisher, "no subject loses more than mathematics by any attempt to dissociate it from its history."[3]

[3] *Nature*, 42: 466, 1890.

BOOKS ON SCIENCE FOR LAYMEN

FORTY YEARS OF SCIENCE[1]

SEVERAL general surveys of science have appeared since the World War. This latest one consists of ten lectures delivered at Cambridge, England, in 1936, the plans for which were developed by the History of Science Committee, of which Dr. Joseph Needham was chairman, and Mr. Walter Pagel was secretary.

The general subject of the lectures was the progress of science in the forty years from 1895 to 1935. Among the speakers were such world-famous scientists as Lord Rutherford, Professor W. L. Bragg, Dr. F. W. Aston and Sir Arthur Eddington. All except Sir William Dampier were actively connected with Cambridge when the lectures were delivered; the addresses by Lord Rutherford and Professor G. H. F. Nuttall were their last ones before their deaths. These lectures were followed in 1937 by a larger series on the earlier history of science. Concerning the reception of these lectures the editors state: "It was for us a moving experience to see the great concourse of students, many having to stand or sit on the floor, which gathered to hear these expositions of progress in the sciences during the past forty years by those who had themselves taken some of the foremost parts in it."

It is evident from the origin of these lectures that they were planned for oral presentation. Indeed, Lord Rutherford's addresses were reported stenographically and put in form for publication after his death. As addresses by distinguished and revered scientists before their students, these discussions of the history of science were a great success. Lord Rutherford and Professor Bragg, for example, could with all propriety and telling effect speak freely and intimately of their own work, but the printed page lacks the warm glow of the person himself. Consequently in general the reaction of a reader of the lectures will fall far short of the response of the students who listened to them.

From the standpoint of the reader the volume lacks close unity, though it is somewhat more than a series of unrelated essays. It is very difficult for a number of authors to adhere closely to a fixed plan and to maintain general similarity of style in preparing a book. To do so would result in a more complete and coherent discussion of some field, but it would be at some cost of freedom and spontaneity of expression. The reader of this volume will feel its lack of completeness and a consistently followed plan. In spite of the fact that the period from 1895 to 1935 was the one under discussion, two lectures by Professor Francis M. Cornford and Sir William C. Dampier begin with the Greeks. Lord Rutherford's two lectures on "Forty Years of Physics" frankly touch only the history of radioactivity and atomic structure, to which he made very important contributions. On the other hand, Professor Bragg's "Forty Years of Crystal Physics" and Professor Aston's "Forty Years of Atomic Theory" are strictly on their subjects and comprehensive, though requiring for their clear understanding a considerably greater background of information in the respective fields than most readers will have. In "Forty Years of Astronomy," Sir Arthur Eddington discusses excellently a number of the principal astronomical advances in the period. Professor John A. Ryle, in "Forty Years of Physiology and Pathology," spent so large a fraction of his space to

[1] "Background to Modern Science." A series of lectures at Cambridge, England, by ten eminent British scientists. xii + 243 pp. $2.00. The Macmillan Company.

earlier periods, especially in well-merited tributes to the remarkable work in gastric physiology of William Beaumont (1785–1853) and to the early work of Ivan Pavlov (1849–1936), as well as to Hunter, de Réaumur, Prout and others, that the modern period, except as to work on the stomach, is very sketchily referred to. Professor G. H. F. Nuttall, in "Forty Years of Parasitology and Tropical Medicine," limits himself to discussions of malaria and yellow fever. The last two chapters on "Forty Years of Evolution Theory" and "Forty Years of Genetics," by Professor R. C. Punnett and Professor J. B. S. Haldane, respectively, have so much subject-matter in common that the fields they were probably intended to cover are not clearly distinguishable. The former, however, is devoted largely to earlier periods, beginning with the Greeks and enlarging on the work of Darwin and his contemporaries; the latter considers much more the work beginning with that of Bateson published in 1895 and that growing out of the discovery of the earlier work of de Vilmorin and Mendel. Among the interesting results of breeding experiments cited are those that resulted in the development of new strains of wheat which have been of great economic importance. As interesting as these two chapters are, one finishes them with the feeling that the authors have only touched lightly here and there on important subjects that would be much more interesting if they were more systematically and thoroughly expounded.

F. R. M.

LIFE AND LIVING FROM AN EVOLUTIONARY STANDPOINT[3]

WITH a healthy skepticism for scientific creed, Dr. Bradley probes into the problem of life and living from an evolutionary standpoint. He is concerned with the racial history of animals and particularly of man. With a fine sense of reality, and a happy turn of quiet humor, Dr. Bradley examines the various patterns of animal existence which have permitted them to survive, or that have at times firmly ordered their extinction. Then, with the anatomy of life exposed from the standpoint of its "musts and must nots" according to the dictates of stern Mother Nature, the author appropriately devotes his closing chapters to man.

The book presents a pleasing, broad, comprehensive, understanding outlook across the various fields of natural science. It passes over the present-day emphasis upon minute details, to bring clearly into focus not the leaves of the trees, but the forest and the geographical topography beneath the forest. The volume is most refreshing for those of us who spend our thinking time dealing with anatomical or physiological detail, and who accept the present without considering seriously the implications of the past.

Dr. Bradley reviews the broad theories of the origin of life with a sense of distrust for such pure speculation. Measuring man's attempt to solve the riddle of the phenomenon of life itself leads him to point out that one frontier conquered brings us only to another blank wall. Even when the mechanism of protoplasm has been dissected molecule for molecule, there is every reason to doubt that the human mind will understand it as a unit or will be able to reassemble it. The probability is strong that the whole has greater and different properties than the sum of its parts.

In evolution, attention is focused not so much upon the importance of change, but upon stability, particularly from the angle of biologic success. Granted that success must always be a matter of opinion, it is likely true that animals which

[3] "Patterns of Survival." By J. H. Bradley. 223 pp. $2.25. The Macmillan Company.

have been in continuous existence for long periods of time are probably more successful than those that became over-specialized and were exterminated. The problem of biologic success is analyzed critically with a view to determine what modes of life, food habits, environment and reproductive factors have been successful for animals in the struggle for existence.

Against a nicely developed background, man is brought into the spotlight. Dr. Bradley holds no halo over his head from the standpoint of present-day anatomy or future anatomical promise. But he does have faith in man's brain and his perpetual discontent. The hope is expressed that man may some day be as successful in controlling his own inner social world as he has been in controlling the outside physical and biologic world.

The book will likely find its way to the reading library of most of us, and surely our students should read it before they become lost in the complexity of detail characteristic of our present-day science.

IRA B. HANSEN
THE GEORGE WASHINGTON UNIVERSITY

BEGINNINGS OF A BILLION DOLLAR INDUSTRY[3]

DR. GIDDENS' book is primarily concerned with developments in northwestern Pennsylvania during the decade which began with the completion of the oil well drilled by E. L. Drake in 1859. The author gives proper emphasis to the fact that although Drake's well was the first one drilled for the purpose of producing oil, oil had been known to be present in springs and salt brine wells in the region for many years. The success of Drake's operation and the high price obtained for oil at that time provided the basis for an astoundingly swift development, which is well portrayed by the author.

[3] The Birth of the Oil Industry. By Paul G. Giddens. 216 pp., 37 plates and maps. $3.00. The Macmillan Company.

The choice of a decade as the time of "birth" of the oil industry is amply justified by the development of production, transportation, refining, marketing and financing activities during this period. Dr. Giddens treats all these phases of the new industry, calling attention to the numerous problems which had to be solved to establish the economic status of the newly developed mineral resource. During this period pipe lines were established for transportation, refining methods to obtain a satisfactory illuminating oil were developed, lamps capable of burning the oil efficiently were invented, and markets were developed in the United States and the principal countries of Europe. The only apparent omission in rounding out the picture is mention of the first application of principles of geology to prospecting for petroleum. A good foundation for the modern application of geology to petroleum exploration was published in a scientific paper by T. Sterry Hunt, of the Geological Survey of Canada, in 1861. During the ensuing eight or nine years several other geologists published statements calling attention to the relationship between geologic conditions and oil accumulation. Structure contour maps were included in a geological report on oil properties published in 1870, so there can be little doubt that they were in actual use contemporaneously with the developments described in Dr. Giddens' book.

"The Birth of the Oil Industry" is not only of considerable general interest but should be of especial interest to those engaged either in the modern petroleum industry, in the development of Pennsylvania or in the operation of economic forces under the American system. Dr. Giddens' book vividly portrays the initiative and resourcefulness of American entrepreneurs of that period. The numerous references included make original data readily available to those interested in further investigation of the subject,

while the "Introduction" by Ida M. Tarbell provides an excellent summary of the book for the use of the less interested reader. "The Birth of the Oil Industry" is to be highly recommended.

GAIL F. MOULTON

IS IT PROBABLE?[4]

THE title "Your Chance to Win" and such chapter headings as "Heads or Tails," "Poker Chances" and "Lotteries, Craps, Bridge" might lead one to conclude that this book is a manual for gamblers. But such other chapter headings as "Fallacies," "The Grammar of Chance," "From Chance to Statistics," "Fallacies and Statistics," "Statistics and Science" and "Business and Statistics" indicate that it probably has a serious side.

As a matter of fact, Dr. Levinson has written a thoroughly scientific work. Instead of proceeding with orthodox academic ponderosity from definitions that have no relation to ordinary experience, he starts with things with which all the world is familiar—with such things as luck and gambling and superstition and fallacies, not in the abstract but in concrete illustrations from things in every-day life. On the one hand, he exposes the erroneous ideas of those who gamble and the improbability of their winning; on the other hand, he makes clear in what sense chance and probability, as they are called, play rôles in the events in which we are interested. In a very entertaining and illuminating chapter on "Gamblers and Scientists" he explains how, in the seventeenth century, what had been thought of as lawless chance was organized into the theory of probability, which has only recently been generally recognized as one of the best tools of theoretical science. In "The Grammar of Chance" he defines very exactly and illustrates clearly the fundamental terms that are used in the theory of probability.

Two or three chapters are devoted to several common games of chance, including tossing of coins, poker and roulette. As entertaining as they are, with sparkling illustrations of human weaknesses and errors in thinking, their real purpose is to give the reader a clear understanding of a subject beset with many pitfalls and to prepare him for straight thinking about the nature and power of statistics in relation to such important and varied subjects as science, advertising and business.

There is probably no other book on the subject of probability and statistics that is so entertaining or that throws incidentally so much light on a certain class of human weaknesses centering in the wide-spread and possibly increasing desire to get something for nothing. At the same time there is probably no other book that makes clearer the real nature of probability and the errors that may be committed in applying the theory of probability. All this is accomplished without the use of complicated mathematical expressions. The discussions of applications of statistics to science, illustrated by Dr. Rhine's experiments on telepathy and clairvoyance, and to advertising and business, relate largely to principles rather than to the mechanics of obtaining numerical results. Yet a reader who has understandingly followed the discussions would be able to apply them safely, much more safely than one could apply formulas whose basic principles he did not fully comprehend.

F. R. M.

[4] "Your Chance to Win." By Horace C. Levinson. 348 pages. Farrar and Rinehart, Inc.

PROFESSOR WALTER B. CANNON

THE PROGRESS OF SCIENCE

PROFESSOR WALTER B. CANNON, PRESIDENT OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

For its new president the association has selected a man in whom an intense devotion to scientific work, tireless energy and a rare gift for framing fertile experimental inquiries have combined to make him one of the world's leaders in physiology and a force in scientific medicine. During the Richmond meeting, where he was elected to the presidency, Dr. Cannon was in New York taking part in another gathering of scientific men. There in conversation with several old students he spoke enthusiastically of experimental results recently obtained and revealed the greatest eagerness to get back as soon as possible to his laboratory in order to push forward the new work. One may confidently predict that during his presidency Dr. Cannon will be in the vanguard of those who are contributing directly to the advancement of science.

Physiologists have two good reasons for interest in the town of Prairie du Chien, Wisconsin. It was there that Dr. William Beaumont, the pioneer of experimental physiology in this country, carried out, during the years 1829–31, some of the most significant of his studies on the "fistulous" Alexis St. Martin, studies which constituted the most important work on the physiology of gastric digestion before the time of Pavlov. And it was there that Walter Bradford Cannon was born on October 19, 1871. Twenty-five years later, while a first-year medical student he began a series of experiments which placed him beside Beaumont and Pavlov as one of the great contributors to our knowledge of the physiology of digestion.

In 1896 he graduated from Harvard College and entered the Harvard Medical School. Very soon he was asking the professor of physiology, Dr. Henry P. Bowditch, for an opportunity to undertake a physiological investigation. Bowditch suggested that the newly discovered Roentgen rays might be used to study the phenomenon of swallowing, and on December 4, 1896, the first experiment was performed when Cannon and a fellow student watched pearl buttons pass down the esophagus of a dog. Almost at once it was found that by mixing bismuth subnitrate with the food both the movements of the gastric contents and the concentrations of the stomach wall could be clearly seen with the x-rays. There followed, over a period of fifteen years, observations and experiments on nearly every aspect and condition of gastro-intestinal motility; in 1911 Dr. Cannon summarized this work in a monograph on "The Mechanical Factors of Digestion."

On his graduation in medicine at Harvard in 1900 Dr. Cannon became an instructor in the department of physiology. Two years later he advanced to an assistant professorship, and in 1906 he succeeded Dr. Bowditch as George Higginson professor of physiology. The studies on the digestive tract terminated in 1912 with the demonstration that the pangs of hunger are due to prolonged rhythmic contractions of the stomach wall. It was at this time that Dr. Cannon conspicuously exhibited a trait which Michael Foster, writing of Claude Bernard, put down as "perhaps the chiefest sign of genius in inquiry." As Foster expressed it, "his instinct guided him to leave the road at the right turning, and to follow a bye-path which brought him a great result." The sign which he heeded was the cessation of gastro-intestinal movements that appeared whenever one of his experimental animals grew restive or displayed anger. Analysis of this phenomenon led to experiments which brought out the important fact that under conditions of physiological stress, such as emotional excitement, asphyxia, exposure to cold

and hypoglycemia, the sympathetic nervous system and its constituent part, the adrenal medulla, act to effect visceral adjustments which are nicely adapted to the preservation of the individual. In 1915 these investigations were reported in the first edition of "Bodily Changes in Pain, Hunger, Fear and Rage." The second edition (1929) contains, in addition to much new evidence bearing on the general theme, an account of some notable experiments on thirst and a fresh theoretical treatment of the origins of emotional behavior and emotional experience.

The relation of the autonomic nervous system to the self-regulation of physiological processes was a major concern of Dr. Cannon for a period of twenty years. Gradually it became clear to him that this system plays an important part in the maintenance of a relatively constant internal environment. The importance of steady states in the organism has been emphasized by a number of physiologists, but nowhere has this concept been presented with such clarity as in "The Wisdom of the Body," which came from Dr. Cannon's pen in 1932.

The present phase of his scientific activity grew out of his final proof of the emergency function of the sympathetic—the brilliant demonstration that after complete removal of this system animals live normally under quiet conditions, but exhibit serious deficiencies when subjected to conditions of stress. Careful examination of a mysterious acceleration of the denervated heart, which appeared with emotional excitement when the sympathectomy was incomplete, led him into the realm of the chemical mediation of nerve impulses, where he was a pioneer. It is not too much to expect that his continuation in this field will greatly elucidate the vexed question of the nature of excitation and inhibition in the central nervous system.

During the Great War the orderly sequence of Dr. Cannon's researches was interrupted by his service as a medical officer. After reaching France he soon engaged in a study of traumatic shock. His observations at the front led to investigations in London and elsewhere which will be of permanent value in explaining the circulatory depression which follows severe trauma. Later, while in charge of the laboratory for surgical research at Dijon, he did much to further the prevention of shock among the wounded.

The honors which have been awarded Dr. Cannon are so numerous that they can not be listed in the allotted space. But it would be a serious omission not to emphasize his personal characteristics. At the celebration of the twenty-fifth anniversary of his professorship Dean Edsall spoke of his possession in abundance of those qualities of personality which produce what we call character; Walter Alvarez, in reviewing the reasons which have made Dr. Cannon such a good foster-father of research, mentioned his open-mindedness to the ideas of others, his genuine interest in the problems of his students and his scrupulous fairness in apportioning credit; and finally President Lowell spoke of a quality which impresses all who know him—his very great modesty.

PHILIP BARD

THE FIFTH WASHINGTON CONFERENCE ON THEORETICAL PHYSICS

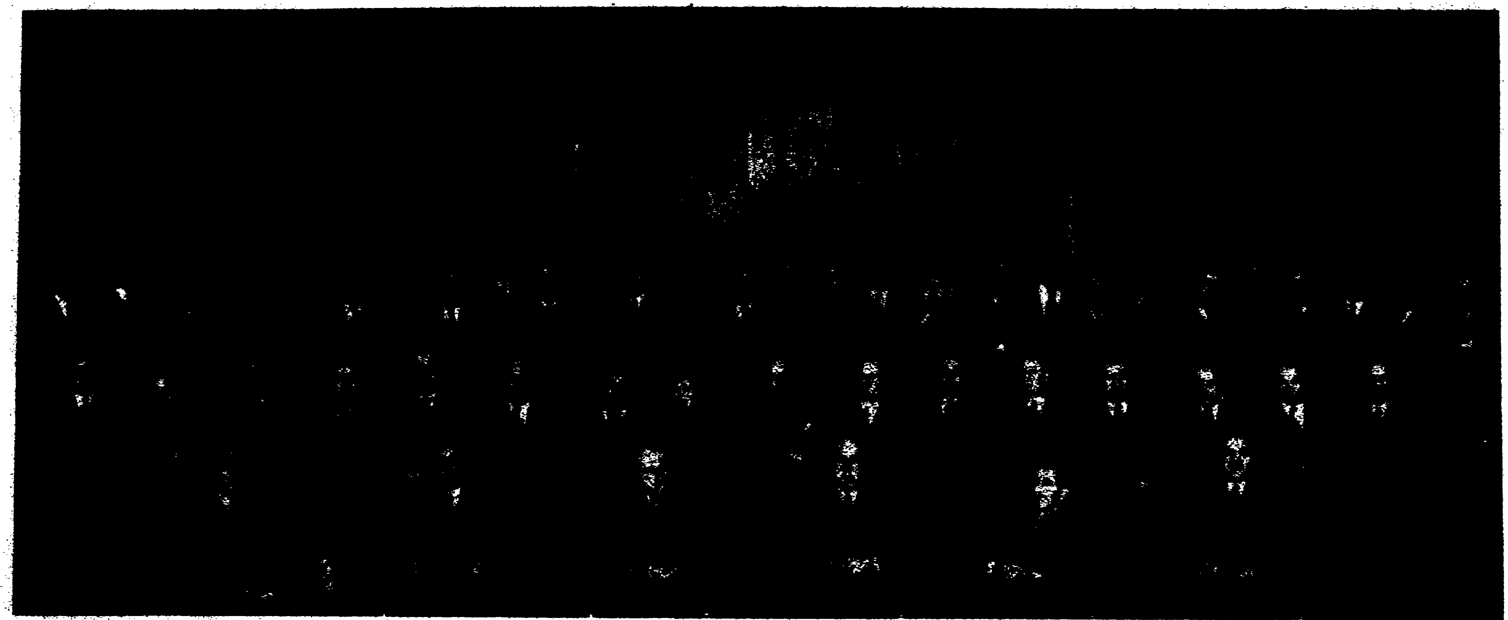
THE fifth annual Washington Conference on Theoretical Physics, jointly sponsored by the George Washington University and the Carnegie Institution of Washington acting through its Department of Terrestrial Magnetism, was held in Washington from January 26 to 28. These conferences afford opportunity for a small number of theoretical physicists investigating related subjects to discuss *informally* fundamental problems and difficulties encountered. Devoted solely to the clarification of the current status of the subject and to discovering the profitable directions for immediate attack, they are uniquely effective in ad-

ATOMIC-PHYSICS OBSERVATORY AND EXPERIMENTAL BUILDING

vancing the progress of researches considered. Vigorous discussion, such as is not possible in a called formal meeting of a scientific society or body, is encouraged and clarifies ideas, clears difficulties and indicates flaws in an argument which frequently an individual fails to see because of lack of constructive and critical contacts. The rapid development in physics during recent years emphasizes the desirability—really necessity—of personal contacts between investigators, who may be widely separated geographically, to facilitate coordination of experimental and theoretical developments. These conferences have proved of real and immediate value in furthering such contacts and understanding and the significance of current experimental and theoretical research.

Among the investigators attending the fifth conference were Professors Niels Bohr, Harold C. Urey and Enrico Fermi, all three recipients of the Nobel Prize. In addition to a number of Washington physicists, there were present Professors F. London, G. E. Uhlenbeck, J. H. Van Vleck, H. A. Bethe, G. Breit, E. U. Condon, I. I. Rabi, A. E. Ruark, F. Bitter, H. Grayson-Smith, F. Seitz, O. Stern, L. Rosenfeld and others. In all, between 50 and 60 men representing 22 universities and research organizations were present at the four sessions during January 26 to 28.

Each conference is planned about some major theme. As in earlier conferences, the aim of the discussions was to clarify the present status of a few important theoretical difficulties and problems in order that investigators actually attacking them might indicate to each other and examine together directions of possible progress. The subject of the fifth conference was the theory of low-temperature physics. The subjects discussed include the properties of liquid helium and of liquid hydrogen and deuterium, the interpretation of data on the adiabatic demagnetization of paramagnetic salts at



PHYSICISTS ATTENDING THE WASHINGTON CONFERENCE

Reading from left to right, starting at bottom row: Stern, Carnegie Tech.; Fermi, Rome, Columbia; Fleming, Carnegie Institution; Bohr, Copenhagen, Princeton; London, Duke, Paris; Urey, Columbia; Brickwedde, Bureau of Standards; Breit, Wisconsin, Carnegie Institution; Silsbee, Bureau of Standards; Rabi, Columbia; Uhlenbeck, Columbia; Gamow, George Washington; Teller, George Washington; Mrs. Mayer, Johns Hopkins; Bitter, Mass. Inst. of Tech.; Bethe, Cornell; Grayson-Smith, Toronto; Van Vleck, Harvard; Jacobs, Mass. Inst. of Tech.; Starr, Mass. Inst. of Tech.; Hebb, Duke; Squire, Pennsylvania; Kuper, U. S. Public Health Service; Mahan, Georgetown; Myers, Maryland; Roberts, Carnegie Institution; Critchfield, George Washington; Baroff, U. S. Patent Office; Bohr, Jr., Copenhagen; Meyer, Carnegie Institution; Herzfeld, Catholic University; Lord, Johns Hopkins; Inglis, Johns Hopkins; Wulf, U. S. Department of Agriculture; Wang, Peking, Carnegie Institution; Johnson, Carnegie Institution; Mohler, Bureau of Standards; Scott, Bureau of Standards; Vestine, Carnegie Institution; Rosenfeld, Liège, Copenhagen, Princeton; Seitz, Pennsylvania; Diecke, Johns Hopkins; Mayer, Johns Hopkins; Hibben, Carnegie Institution; Tuve, Carnegie Institution; O'Bryan, Georgetown; Hafstad, Carnegie Institution; Cohen, Columbia; Hoge, Bureau of Standards; Sklar, Catholic University; Rossini, Bureau of Standards.

temperatures below 1° absolute, and the phenomenon of superconductivity. Differences in the physical properties of the isotopic modifications of hydrogen at low temperatures were also discussed.

Professor F. London, of the Institut Henri Poincaré of the University of Paris, who has been visiting professor at Duke University for some months, presented his recently developed theoretical considerations concerning many striking phenomena observed in liquid helium below the transition-point at 2°.2 absolute. He also discussed the theory of superconductivity.

Professor Van Vleck, of Harvard University, and others referred to recent considerations bearing on method of Giauque and Debye in obtaining temperatures below 1° absolute by the adiabatic demagnetization of a paramagnetic salt and on the property of matter at these temperatures. In considering the experiments of Simon, Kurti and coworkers on iron ammonium alum at temperatures below 1° absolute, Drs. Hebb and Squire pointed out that magnetic properties provide the only thermometer available for such measurements. Yet temperatures as low as 0°.006 absolute are attainable only because magnetic anomalies exist at these very low temperatures. The reduction of the magnetic temperatures to the absolute scale was critically reviewed.

An unexpected event at the conference was the first information in this country given by Professors Bohr and Fermi regarding the chemical discovery of Professor Hahn and his coworkers of disintegration of uranium into the comparatively light element barium (and other residues), with the attendant release of approximately two hundred million electron-volts of energy per disintegration. The physical interpretation of this was first made by Frisch and Meitner. As indicated elsewhere in this issue of The Scientific Monthly, direct experimental observation of such disintegration was independently accomplished at Copenhagen on January 15, at Columbia on January 25, and at Johns Hopkins and the Carnegie Institution of Washington on January 28.

A more detailed account of the scientific discussions will be published in *Science*. The results, as in the past four years, indicate conclusively the value of such "working conferences" in which a small group of men actively engaged in theoretical research may be invited to take part. They are particularly appropriate and effective in developing interest in the fundamental aspects of the theoretical and experimental researches in nuclear physics and magnetism being developed at the George Washington University and at the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. It is hoped that the example set by the sponsors may be followed more generally by institutions lo-

GEORGE WASHINGTON UNIVERSITY BUILDINGS

SHOWING, LEFT TO RIGHT, COLUMBIAN HOUSE, THE BIOLOGICAL SCIENCE BUILDING, THE LISNER LIBRARY (RECENTLY TORN DOWN TO MAKE WAY FOR A NEW LIBRARY NOW UNDER CONSTRUCTION) AND THE SOCIAL SCIENCE HALL.

cated at other scientific centers. The success attending the Washington conferences makes it increasingly clear that fields of such possibilities so thoroughly investigated in detail require limitation each year to a few specific topics. Thus the need for limiting the number of invited conferees is generally recognized.

JOHN A. FLEMING,
Director
DEPARTMENT OF TERRESTRIAL MAGNETISM,
CARNEGIE INSTITUTION OF WASHINGTON

SPLITTING OF URANIUM ATOMS

ALMOST simultaneously near the end of January four experimental laboratories equipped with very high voltage electrical machines announced that they had verified the breaking up of uranium atoms into two roughly equal parts. The disintegration of the uranium atoms was produced by bombarding them with neutrons, one of the fundamental constituents of which all atoms are composed. Sensational press statements concerning the experiments played up the fact that when an atom of uranium is caused to divide into two parts by a bombarding neutron, it gives up enormously more energy than is carried into it by the neutron. This fact does not suggest the way to a new almost limitless source of energy, because in obtaining the neutrons for the bombardment much more energy is used than the uranium releases. In the domain of physics there is as yet no promise of being able to get something out of nothing.

In order to make clear the importance of these experiments it may be desirable to recall a few of the properties of atoms and of uranium in particular. A common description of atoms is that they are somewhat similar to miniatures of the solar system, consisting of central nuclei containing most of their mass and negative electrons revolving around the nuclei as the planets revolve about the sun. It is misleading, however, to carry the analogy far, for in very important respects atoms are quite unlike the solar family. The experiments under consideration pertain to the nuclei, though the chemical properties of atoms depend almost entirely upon their outer negative electrons. It is the atomic nuclei that contain the keys to the most important properties of matter, including explanations of the principal sources of the energy radiated by the stars. For this reason the recent experiments are of great interest.

Historically the sequence of experiments began in October or November when Professor Hahn and Dr. Strassmann, in Berlin, found radioactive barium in uranium which had been bombarded by neutrons. Uranium, with an atomic weight of 238, is a radioactive element which spontaneously degenerates into lead through a series of about a dozen steps in which small particles are successively emitted. The degeneration stops at the one of isotopes of lead which has an atomic weight of 206. Since the atomic weight of radioactive barium is about 139, it could not come from uranium by the previously known type of degeneration. For this reason Hahn and Strassmann at first suspected that the barium which they found in uranium which had been bombarded with neutrons was an impurity in the original materials.

The experimental results obtained in Berlin were communicated to Professor R. Frisch, at Copenhagen, and Dr. Lise Meitner, an exile from Germany. They suggested that the barium which had been found might have been produced by division of the uranium nuclei into two roughly equal parts. Moreover, they outlined an experimental test of the hypothesis which was based on the fact that in the suggested splitting up of uranium there would be a known decrease in total mass through what is known as the "packing effect" with a corresponding release of energy, in conformity with the principle that the sum of mass and energy, in suitable units, is constant whatever transformations they may undergo.

THE ATOMIC-PHYSICS OBSERVATORY

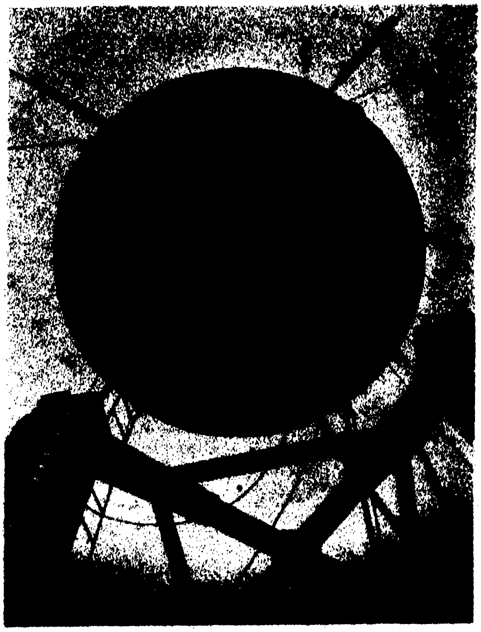
TAKEN BY THE LIGHT OF THE FULL MOON. THE CURVED STAR TRAILS SHOW THAT THE CAMERA WAS POINTED NORTH, AND THAT THE EXPOSURE WAS A LONG ONE.

AN INTERIOR VIEW OF THE ATOMIC-PHYSICS OBSERVATORY

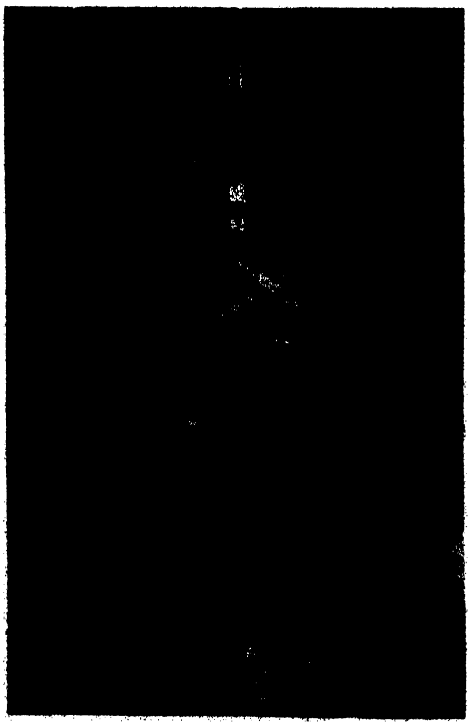
Since a minute quantity of matter is equivalent to a great amount of energy, the calculated energy released in this process would be very large.

Frisch, in Copenhagen, found the predicted energy effects in about the middle of January, but they were not made public. They were found wholly independently by Drs. Dunning and Pegram at Columbia University on January 25, and also independently and simultaneously, on January 28, by Drs. Fowler and Dodson at Johns Hopkins University and by the physicists of the Terrestrial Magnetism Laboratory of the Carnegie Institution of Washington.

In the fields of cosmic rays and nuclear physics scientists express energy in terms of electron-volts, a term derived from the acceleration of negative electrons by a difference in electrical potential. In the experiments under consideration it was found that uranium was broken up by



THE 19-FOOT HIGH-VOLTAGE BALL BEING LOWERED ONTO THE 26TH PORCELAIN SUPPORT-COLUMNS INSIDE THE 5,000,000-VOLT ATOMIC-PHYSICS OBSERVATORY OF THE CARNEGIE INSTITUTION DEPARTMENT OF TERRESTRIAL MAGNETISM IN WASHINGTON.



neutrons having surprisingly low velocities, of the order of one mile per second. Thus when an atom of uranium was bombarded with a neutron having an energy of 1/30th of an electron-volt it broke up with the formation of barium, and the energy released in the process amounted to about 250,000,000 electron-volts per atom. But the most efficient known means of obtaining a slow neutron to break down a molecule of uranium requires the expenditure of about 3,000,000,000 electron-volts of energy. Therefore, disregarding the scarcity of uranium, the process has as yet a maximum energy efficiency of less than 10 per cent.

The chief importance of this discovery is no doubt the added information that it gives regarding the structure of the atomic nucleus. The fact that such a relatively large amount of energy is evolved in each individual atomic disintegration is of striking interest.

M. A. Tuve

THE ASSOCIATION—PAST, PRESENT AND FUTURE

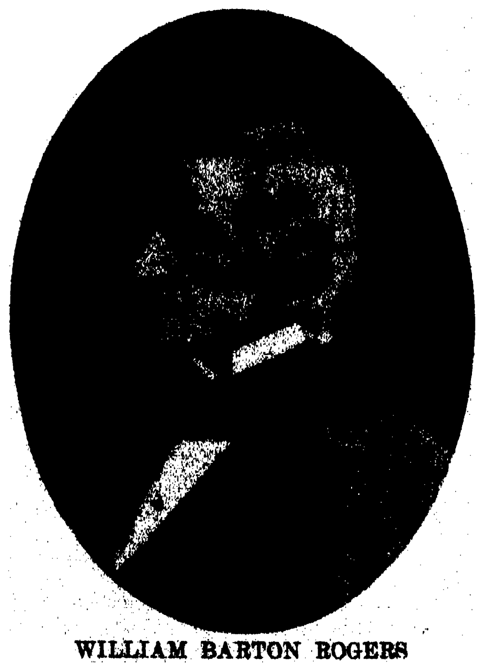
In a recent number of the Monthly two different men were said to have been the first president of the American Association for the Advancement of Science, one writer assigning the presidency to the chairman of the organizing committee. Since my memory doesn't reach back to the first meeting, which was held in Philadelphia on September 20, in 1848, I have looked up the early history of the association and also a few statistics relating to its membership from its origin down to the present time.

For several years previous to 1848 there had been considerable discussion in this country about organizing a truly national scientific society. At that time science consisted of two general divisions, natural philosophy and natural history, the former including the physical sciences and the latter the biological. The material resources of the country naturally aroused great interest in the physical sciences, especially geology, and the relatively unknown fauna and flora stimulated an equal interest in the biological sciences. The obvious advantages of a general society including all the sciences had been exemplified by the British Association for the Advancement of Science, which was organized about sixteen years earlier.

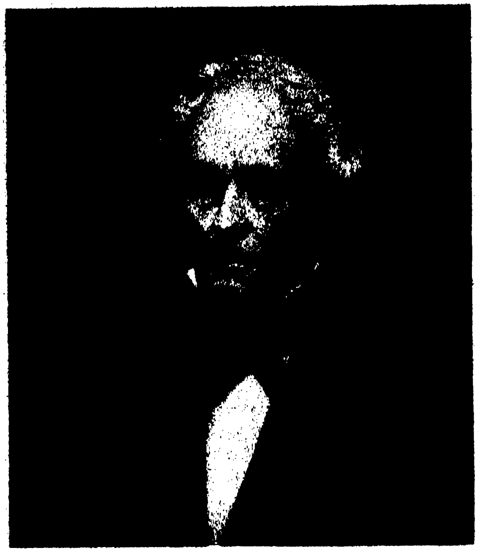
At a meeting of the Association of American Geologists and Naturalists, held on September 24, 1847, the first officers of the newly formed American Association for the Advancement of Science were elected. William C. Redfield was chosen president of the association for 1848, Professor Walter R. Johnson, secretary, and Professor J. Wyman, treasurer. Professor William B. Rogers, of Virginia, was chairman of this meeting, as well as of the first meeting of the association held in Philadelphia the following year. Thus the first officers of the association were elected in September, 1847, and its first meeting was held in September, 1848. The association has held at least one meeting each of the 91 years since its organization, except in 1861 to 1865, inclusive. The Virginia meeting held in Richmond in December was the one hundred third regular meeting of the association, in addition to the meetings of the Pacific Division and of the Southwestern Division.

For many years the number of members of the association was not so great that it was necessary to hold its meetings only in cities having accommodations for large conventions. Its total membership during the first thirty years of its existence did not exceed a thousand, and usually only a few hundred persons attended its meetings. During these years it could meet in such cities as Newport, R. I., Troy, N. Y., and Dubuque, Iowa. Now its winter meetings can be held only in cities having accommodations for at least 5,000 scientists.

One of the great advantages of meet-



WILLIAM BARTON ROGERS



WILLIAM C. REDFIELD

ings of scientists from various fields is the opportunities they offer for extending acquaintanceships, especially among those in different fields, because specializations have gone so far that cooperative work and integrations of science are becoming daily more and more important. In order to increase these advantages the meetings should be a little more leisurely, with the rigors of scientific sessions interspersed more freely with social gatherings and excursions. Perhaps the custom of the British Association of beginning its meetings near the middle of one week and continuing them over into the following week, with Saturday and Sunday free from formal sessions, is one that might be advantageous to the American Association. A longer meeting presents, of course, an economic problem that is often important for younger scientists. At Richmond a large number of them were provided excellent accommodations in what are known as Tourist Homes, which were not at all makeshift places for staying over night but high-grade residences in which paying guests are received. The possibilities in this direction have not begun to be explored. But this is somewhat aside from the subject under discussion except as it bears on the future growth of the association and the increases in the size of its meetings.

A bird's-eye view of the progress of science in America and of the growth of the association can be obtained from its membership by decades. Since its fiscal year ends on September 30, the following statistics are for that date except in the case of the last one, February 4, 1939.

YEAR	MEMBERS	MEETING PLACE
1848	461	Philadelphia
1858	962	Baltimore
1868	686	Chicago
1878	962	St. Louis
1888	1,964	Cleveland
1898	1,729	Boston
1908	6,072	Chicago
1918	?	Baltimore
(1920	11,442	St. Louis)
1928	16,328	New York
1938	19,347	Richmond
1939 (Feb. 4)	20,048	

What of the future of the association? Of course no one can answer, though prophetic curves similar to those which statisticians employ could be developed. The need for the fundamental creed of science that only truth is a worthy and an acceptable goal, whatever it may be, is acute in the world. The world needs equally the sincerity of science, its singlemindedness, its adventurous spirit, its honesty, its altruism—to use an old-fashioned word, its righteousness. It cries for science to lay down a new foundation for relations among men—a new basis for morals. What an obligation rests on science and what an opportunity is at hand for making its principles living forces in the world! Columbus only discovered a new continent; science has within its power the creation of an entire new world. What of the future of the American Association for the Advancement of Science? Civilization asks the question.

F. R. MOULTON

THE PROPOSED PUBLIC HEALTH PROGRAM

In a special message to Congress on January 23, President Roosevelt submitted to the legislature for careful study the report and recommendations of the Federal Interdepartmental Committee to Coordinate Health and Welfare Activities for a national health program. Senator Robert F. Wagner, of New York, stated in a radio address on January 30 that he is now drafting legislation to make this broad-guage plan a national reality.

The program presented to Congress had its origin in the cooperative efforts of federal agencies to make the health and welfare benefits of the Social Security Act quickly and effectively available to the general population. Three years of study on the part of the federal officials who form the membership of the Interdepartmental committee and its technical subcommittees served to focus attention on the uneven distribution of health services and medical care, and on the need for more adequate provision of public health and medical services as reflected in terms of preventable disease and death, costly disability and dependency. Accordingly, a preliminary plan to provide a better distribution of health facilities and medical services throughout the nation was prepared by the Technical Committee on Medical Care and submitted to the President in February, 1938, In July, at the suggestion of the President, a group of some two hundred men and women met with the Interdepartmental Committee in Washington to discuss the proposals of the committee and to facilitate an expression of opinion on the part of the several professions and consumer groups concerned with the provision and receipt of health services.

The recommendations of the committee require objective study. They should be considered on the basis of the statement of needs and of the objectives of the program which forms the opening sections of the report. Dr. John Punnett Peters, professor of clinical medicine of the Yale Faculty of Medicine, recently stated that the program submitted by the committee "bears the marks of statesmanship, rising above political expediency. The problem is clearly defined and measures for the treatment of each major phase are outlined. The federal government is not given undue predominance; administration is entrusted to local and state authorities; proposals are stated in general terms only; the means to implement them and the machinery to execute them are wisely consigned to further discussion and experiment; gradual, evolutionary development is contemplated."

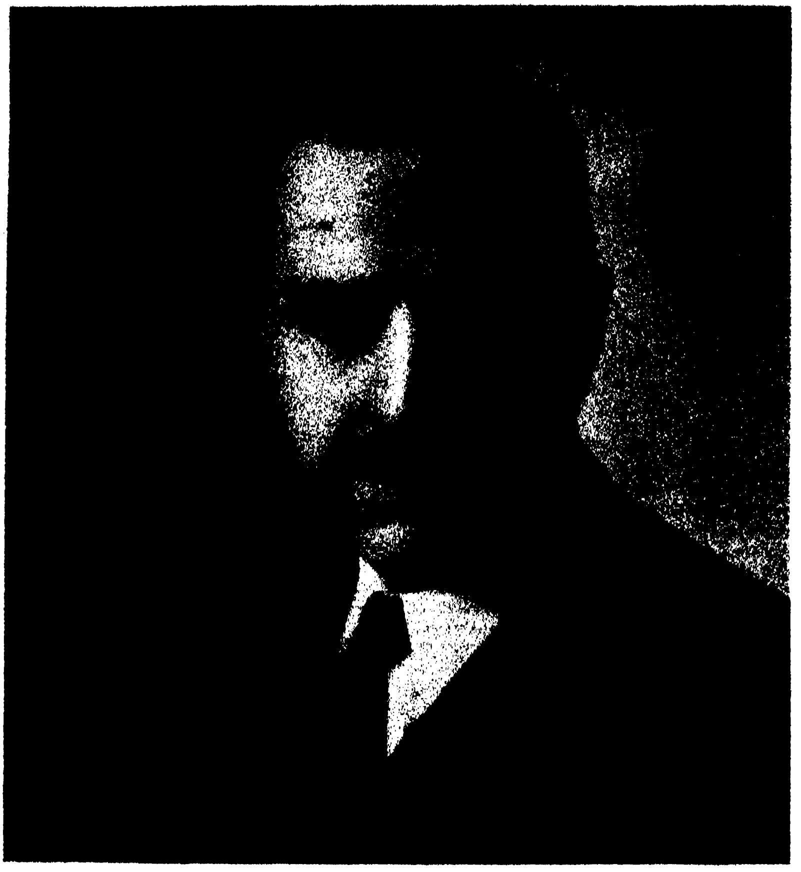
The recommendations of the Interdepartmental Committee lay down four lines of approach which form a coordinated plan for the improvement of national health. They are briefly:

(1) The expansion and strengthening of existing federal-state cooperative health programs under the Social Security Act, with special reference to public health organization, maternal and child health services, the care of crippled children, the control of tuberculosis, venereal diseases, pneumonia, cancer, mental disease, malaria and industrial disease and accident.

(2) The construction, enlargement and modernization of hospitals and other physical facilities for good health, where these are non-existent or inadequate. Federal grants toward maintenance costs of new institutions during their first years of operation are also proposed.

(3) Grants-in-aid to the states to assist them in developing sound programs of medical care which will take account of the needs of all persons who now receive inadequate medical care. The origination, the organization and the administration of such programs are left to the states.

(4) The development of social insurance to provide partial compensation in



DR. THOMAS PARRAN

SURGEON-GENERAL OF THE U. S. PUBLIC HEALTH SERVICE, WHO WAS AWARDED THE WILLIAM FREEMAN SNOW MEDAL FOR DISTINGUISHED SERVICE TO HUMANITY, BY THE AMERICAN SOCIAL HYGIENE ASSOCIATION AT ITS 26TH ANNUAL MEETING ON FEBRUARY 1.

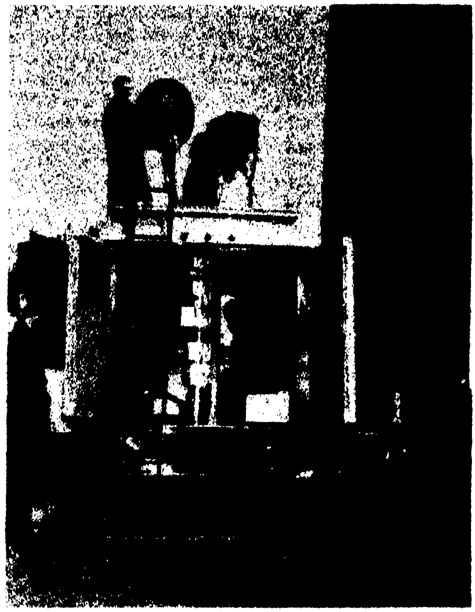
lieu of wages to those temporarily or permanently disabled by disease or injury.

Dr. Thomas Parran, Surgeon General of the U. S. Public Health Service, in an address to the National Health Conference said: "Those of us who are concerned with the progress of medical science usually think that the great events of medicine occur only in the research laboratory or the operating room. We are witnessing here another kind of progress in medicine—an effort to put medical science to work. The National Health Conference may well be the greatest event in medical science which has happened in our time."

The significance of this statement to applied science can not be overestimated. It signalizes the revitalized appreciation on the part of science of its responsibilities for the social advance of the civilization it serves. It foreshadows a fresh impetus to progress in every branch of science. Medicine has contributed discoveries of the utmost importance to the mechanical and biological sciences; it has, in turn, drawn upon the inventions and discoveries of every scientific discipline for the means to further man's attack on disease and death. Only when the contributions of science are used to the fullest extent are new problems set, new demands made, new discoveries possible.

TELEVISION IN WASHINGTON

The first public demonstrations in Washington of recent developments of television by the National Broadcasting Company and the Radio Corporation of America were made at the end of January. The equipment used in picking up the things that were being transmitted consisted of two units, one roughly like a small tent equipment with Klieg lights and the other looking much like a private railroad car. All this equipment was located on the Mall near the buildings of the Department of Agriculture. The receiving sets were installed in the National Press Building, approximately half a mile distant.



MOBILE TELEVISION UNIT
SHOWING ICONOSCOPE CAMERA AND MICROPHONE, AT THE MOMENT ON TOP OF THE VAN HOUSING THE CONTROL ROOMS, AND THE CABLE FOR PASSING TELEVISION SIGNALS FROM THE CAMERA TO THE TRANSMITTER VAN. SIGHT AND SOUND ARE PICKED UP BY THE ICONOSCOPE CAMERA AND PARABOLIC MICROPHONE AND SENT THROUGH SEPARATE CABLES TO THE CONTROL ROOM.

AMBASSADOR IN PHOTOGRAPH AND BY TELEVISION
THESE TWO PICTURES OF COUNT JERZEY POTOCKI, POLISH AMBASSADOR TO THE UNITED STATES, SHOW THE RELATIVE CLEARNESS OF AN ACTUAL PHOTOGRAPH WITH A REPRODUCTION IN THE ICONOSCOPE DURING THE RCA–NBC TELEVISION DEMONSTRATIONS IN WASHINGTON, D. C.

The "performers" were various persons drafted extemporaneously for the purpose, most of them being well known in Washington. The continually changing audience in the National Press Building consisted of the performers and many other invited persons. The results were not only extremely interesting but excellent. Every person making an appearance was as easily recognized as in an ordinary non-professional motion picture and the reproductions of the voices were entirely satisfactory. Although transmission by wire is used freely from studios to transmitting stations and between cities in our ordinary broadcasting the connection between the field equipment and the receiving sets was only by radio, as it will necessarily be in

many cases when television passes from the experimental to the commercial stage.

At the present time between 75 and 100 receiving television sets are in use in New York by officials of the interested companies, in addition to an unknown number of sets constructed by amateurs. The R.C.A. hopes to have receiving sets available for the public within a few months. In spite of the remarkable success of developments to date, the technical and practical difficulties of television are so serious that its wide use in the future would not appear very promising if we did not have before us the astounding example of the radio. It should be insisted, however, that in television very serious problems are present that do not arise in ordinary radio.

F. R. M.

AGE OF METEORITES

A FEW minutes' watch of the sky on any clear night is almost certain to show one or more sudden streaks of light produced by meteors dashing into the earth's upper atmosphere at high speeds. We know that some of these wanderers from space have been permanent inhabitants of the solar system, for their velocities relative to the sun are less than 25 miles per second. Others of them have traveled the interstellar spaces. The distances between the stars are so great that 15,000 years would be required for a meteor to come from the nearest star to our system if it moved with a constant velocity of 50 miles per second.

Most meteors are so small that the energy of their motion transformed into heat in the high upper atmosphere of the earth entirely consumes them. Occasionally, however, one is so large that it survives its fiery bath and is eased down by the atmosphere to the surface of the earth. These meteorites, as they are called, are often recovered, a few each year, and are preserved in our museums and scientific institutions.

Since meteorites are the only visitors from the celestial spaces, they are of extraordinary interest. Essentially all other information about the universe beyond our earth comes to us through light. One of the questions that always arises when we consider meteors is their ages. The answer to this question, taken together with their chemical and physical constitution, will throw light on their origin and possibly on the origin of the earth.

As is well known, the best method of determining the ages of terrestrial rocks is based on the extent to which their uranium and thorium compounds, if any can be found in them, have degenerated through radioactive transformations. By this method it has been found that certain terrestrial rocks are 1,850,000,000 years old, the most ancient at present known. This is not, however, the age of the earth, for these rocks in which the uranium has been found are intrusions in older rocks.

If meteorites contain uranium their ages can be similarly determined. Fortunately many meteorites do contain small quantities of uranium and other radioactive elements. Dr. Robley D. Evans, 1937 winner of the Theobald Smith Award in Medicine of the American Association for the Advancement of Science for his work on radium poisoning, has recently made a survey of all determinations of the ages of meteors. He states that the typical meteorite contains about one part of uranium in ten million parts of other elements. As soon as the meteorites were formed or became separate bodies their uranium clocks began steadily to tick off the millions of years of their wanderings. According to

investigations of 23 iron meteorites, their ages range all the way from 2,800,000,000 years down to about 100,000,000 years, with approximately uniform distribution over the range. Although there are considerable uncertainties in the determinations, eight of the 23 specimens are older, but not greatly older, than any terrestrial substances whose ages are known.

F. R. M.

DETECTION OF CARBON MONOXIDE IN MEDICINAL OXYGEN

The revision of the United States Pharmacopoeia has become a continuous process. Research on new and old drugs is constantly in progress in the laboratories of the subcommittee chairmen of the General Committee of Revision. Supported by funds from the Board of Trustees of the United States Pharmacopoeial Convention, Dr. Frederick K. Bell has been working on the standards for and the assays of the medicinal gases of the Pharmacopoeia in the Department of Pharmacology of the School of Medicine of the University of Maryland for two years.

The detection of carbon monoxide in medicinal oxygen is an extremely important medicinal problem. The present official method which depends upon the reduction of iodine pentoxide at an elevated temperature by carbon monoxide is non-specific and traces of other substances such as ethylene and acetylene respond positively to this test. The presence of such a large quantity of oxygen makes the carbonyl hemaglobin test far less sensitive than required for this purpose. Dr. Bell has observed that freshly prepared alkaline solutions of sodium hydrosulfite will absorb the oxygen and leave behind the impurity, carbon monoxide, if it is present. Thus by adding a very small volume of nitrogen to a large volume of oxygen and allowing the hydrosulfite to absorb the latter gas, the carbon monoxide may be greatly concentrated in the nitrogen. Besides, most of the oxygen which has an affinity for the hemoglobin is removed. Using freshly drawn dog's blood, Dr. Bell has been able to detect specifically carbon monoxide in oxygen in concentration of 5 parts per million.

John C. Krantz, Jr.

THE USE OF TEAR GAS TO FIGHT WEEDS

Back during the world war, tear gas was one of the weapons of military offense. Many a crucial objective was gained while its defenders were weeping, helplessly, like small boys.

To-day, when strikes and riots prevail, tear gas is the weapon used by police to reduce crowds, temporarily, to non-resistance.

But next year, perhaps, tear gas will find a new use and one far removed from violence. It will help produce weed-free putting greens for the nation's golfers!

J. A. DeFrance, of the Rhode Island Experiment Station, traces the use of tear gas to kill weeds back to the shell-battered No Mans Land of France. The gas squads of wartime contained men trained in chemistry. One of them noticed that where the tear gas liquid spread on the ground, weeds were quickly killed.

Out of this remembrance has come soil sterilization by tear gas which renders the future soil of golf greens free of weeds.

In the present practice the soil destined for the green is placed in a large box and several holes drilled in the earth. Down each hole are poured a few drops of liquid tear gas, a canvass cover applied and left for about two days.

The soil is then removed and placed directly on the golf green and seeded. All the weeds in the soil are killed and the grass takes root without competition from its fast-growing rivals. The putting green is thus free from weed contamination until wind-blown weed seeds alight on it and take root, something which is not too easy when a thick, velvety coat of grass is already there first in husky growth.

Commonest sterilization method for greenhouse soils is the application of live steam while heat, applied by flame, is often used in outdoors locations such as highway roadsides and railroad rights-of-way.

SCIENCE SERVICE ROBERT D. POTTER

MUSICAL ABILITY

You need not be a great composer or an orchestra leader to be credited with the blessing of a musical mind.

Musical talent is bestowed on man in a great variety of forms and degrees, and the ignorant railroad worker enjoying the rhythm of his hammer blows has his share as does the suave critic at the opera.

Underlying all musical ability are the four sensory capacities of apprehension of pitch, loudness, time and timbre, it is pointed out by Dr. Carl E. Seashore, psychologist student of musical talent in analyzing the musical mind as part of his new book, "Psychology of Music" (McGraw-Hill).

These four capacities, and their more complex forms, the sense of tone quality, of volume, of rhythm and of consonance Dr. Seashore calls the four great branches of the musical family tree. They are inborn and are fully developed in the very young child. By the age of ten they can be measured, so that the child's native musical talent can be estimated before his training.

A great musician tends to have these four trunks of capacity branching out in balanced and symmetrical form, but in most of the less distinguished musical minds some one branch is dominant.

Musical achievement does not depend upon great capacity in all these lines, Dr. Seashore says, so long as the individual follows the line of his ability. If a person has only average sense of pitch, for example, he should not try to be a singer or violinist, but he may become a pianist of great distinction.

With the underlying trunk of sensory capacity, the musical mind has the ability to hear with his "mind's ear." He must live in a world rich in auditory images. He must be able to hear over music in memory and create new musical structures in his imagination.

The musician must be able to think musically. He must have musical intelligence.

And finally he must be able to feel musically and express a wealth of emotions in music by esthetic deviation from the regular and rigid.

SCIENCE SERVICE

THE SCIENTIFIC MONTHLY

APRIL, 1939

HUMAN NEEDS AND SOCIAL RESOURCES

By Dr. C. MACFIE CAMPBELL

MEDICAL DIRECTOR, BOSTON PSYCHOPATHIC HOSPITAL; PROFESSOR OF PSYCHIATRY, HARVARD UNIVERSITY

MENTAL health is the concern not only of the medical scientist and practitioner, and of the other scientists dealing with man as an individual and in his group relations, but is the concern of every citizen.

In this paper I propose to comment on various topics within the field of mental hygiene, hoping that the discursive nature of my remarks will not obscure the main theme, *viz.*, "Man and His Needs."

The recent symposium on mental health, sponsored by the American Association for the Advancement of Science, was an expression not of mere scientific curiosity, but also of grave practical concern, perhaps even of a certain impatience. In face of material difficulties and of the ravages of disease, man in the past appealed to his gods; modern man turns to the scientist. The scientist has responded to the appeal. He has given to his fellows control over the forces of nature to a degree undreamed of even by our grandparents. He has achieved signal triumphs over the forces which threaten the health of man. He has curbed the ravages of infectious disease, such as smallpox, typhoid fever, diphtheria. He has traced those subtle components of man's diet in the absence of which thousands have perished from scurvy, pellagra, beriberi. He has multiplied procedures for the prevention and cure of disease. The diabetic and the anemic resume efficient lives, radiant energy is harnessed for healing purposes; anesthesia has made surgery painless, asepsis has made it safe. The laity eagerly welcomes and applies each new medical discovery that promises immunity from disease, relief from pain; with individual exceptions—anti-vaccinationists exist, some people refuse to eat their spinach.

With such triumphs as the aforementioned in the field of general medicine, what steps are being taken towards the conquest of mental illness which strikes at the very core of the human personality? What progress is there to report in this field? At first sight the facts are disconcerting; statistics record no decrease in the total number of those suffering from mental disorders, they record an increase in the number of those admitted annually to the mental hospital. The taxpayer groans under the economic load of to-day, looks forward uneasily to the increasing burden of to-morrow.

In situations of difficulty personal discomfort is partly alleviated by transferring the feeling of personal responsibility to external objects; the scapegoat—an animal with a long and interesting history—is not yet extinct. In the present case a scapegoat may be found in the group of medical scientists and practi-

tioners, who are specially occupied with the study and treatment of mental illness. If one could transfer all responsibility to them, the conscience of the lay community and of the general medical profession might remain at rest. But the dominant consideration at present is that of constructive work, and of the respective contributions which can be made to such constructive work by the lay community, various special sciences, the general medical profession and the psychiatric group. It is in the interest of such constructive work that the symposium was held; its keynote was the desire to understand more clearly the nature and extent of this important medical and social task.

In the symposium one took stock of the situation, outlined facts, considered procedures. One may also have to outline goals. The goal in this field of medical work may be to help people to live *well*, not merely to safeguard them from external dangers; it may be to help people to put forth effort more *wisely*, not to help them to get along more easily. In talking of living well and wisely I realize that I am getting into deep water. My defense is that life is in deep water, that it is in the deep water of human life that mental disorders develop. If we are to help our fellows in their lives we must take some risks, and forego the solid support of a purely intellectual structure; life is more than science, it is an adventure of the spirit with nothing absolute and guaranteed. In face of our mental patients we have to deal with life in all its fulness.

The Scientist and the Study of Man

The symposium dealt with mental health, the health of the individual human personality as judged by its internal equilibrium and its adaptation to the physical and cultural forces surrounding it. Many groups of scientists deal with man. The physiologist gains ever deeper insight into the physical and chemical processes of the bodily tissues, into their integration and their adaptive significance. The social scientists investigate the social setting in which the life of the human individual runs its course. They make a systematic study of the various groups of which the individual is a member, and whose influence is an integral part of the individual's personality. They study the facts of family life, economic life, industrial life, political life, and the associated customs, traditions and institutions. They study individual man and human culture throughout their evolution in history. They make comparative studies of the various cultures of modern man, his crafts, his domestic and social habits, his beliefs and rituals. With their rich harvest these scientists have deepened and broadened our conception of man, so that in a discussion of man's mental health the terms we use involve a tacit reference to these gains even when the latter are not explicitly referred to. Scientists from diverse fields, as well as physicians, contributed directly to the symposium—biologist and physiologist, psychologist, economist, sociologist, statistician, anthropologist, political scientist, administrator, lawyer, pastor. They brought to the discussion data and conclusions gained in their special fields by their own methods.

The collaboration of the scientist in the field of mental hygiene may be not without its own reward. The study of the human personality from the point of view of mental hygiene may contribute something to the thought of the physiologist and of the anthropologist, of the economist and the sociologist. Scientists working from different angles on the same material establish a common frame of reference somewhat broader and more adequate than the narrow frame of reference to which the individual sciences seem to restrict the specialized worker.

This development of a broad frame of reference through scientific collaboration between different disciplines may be of special value when, as is sometimes the case, the scientist becomes philosopher. He is then apt to step outside of his familiar frame of reference and without revision of his categories to present us with a rather startling view of the universe; his prestige as a scientist may then give undue weight to a rather one-sided philosophy.

To those scientists who have not taken human activity either in its individual or group manifestations for their object of study, the analysis of the human personality has, too, a certain importance. For even where man as object is not of importance, man as subject has to be taken into account. The scientist, a human being, enters as observer into every observation. To the scientist, therefore, man presents a dual interest, as part of the cosmos and as an instrument of observation. As he scrutinizes his apparatus, recognizes its limitations, measures carefully its possibilities of error, so he must make allowance for his own limitations. He is an instrument of very complex structure. The astronomer, in making an accurate observation of time, makes allowance for his own personal equation, the slight distortion for which he himself is responsible He thus does justice to the fact that the world of his observation has a certain subjective quality. The scientist may find on examination that this subjective quality reaches further than he thought. He may become aware of unsuspected subjective factors which determine the trend of his interests in research, influence his observations and his conclusions. He may note with Charles Darwin that any facts and thoughts unfavorable to his own results are more apt to escape from memory than favorable ones. He may be chagrined to realize that his insistence on certain scientific formulations is partly determined by unacknowledged jealousies and antagonisms. He may wonder whether the unusual emphasis on precision and detail on which he has prided himself as a virtue may be after all in part a neurosis.

So in the specialized field of intellectual activity of the individual scientist, unrecognized elements in the personality may intrude. The scientist in alarm may wonder how far in his general philosophy of life and in his daily scheme of values these same elements play a part. Even to him mental hygiene may have a practical message. It is time, however, to discuss the general state of affairs, to discuss problems, men, methods, money.

The Field of Mental Hygiene

To introduce the topic of mental health by discussing mental illness is somewhat misleading. Mental health is more than the absence of mental illness, it is the condition in which the individual attains a certain internal equilibrium and adequate self-expression, utilizes the fulness of his endowment, has a moderate feeling of well-being or joy, makes his contribution to the life of the community. Merely to rub along in a way which attracts the attention of nobody and without any gross personal dissatisfactions is a poor standard of mental health. We must not be content with the physical status of a listless and undernourished child on the ground that he has no recognized type of physical disease. We must not be content with the mental health of a community where opportunities for artistic and intellectual satisfactions, for group activities and recreations, are negligible and where the individual lives a narrow and stunted life.

Our conception of mental health should be positive and constructive, but the crude facts of mental illness stare us in the face, make immediate demands, give us food for thought, teach us many lessons. We find that there are almost half a million patients in the special hospitals

of the United States suffering from overt mental illness, an uncounted number of patients with similar illness living in the community, a still larger number of patients with disorders of the personality which masquerade as physical invalidism, nervous troubles, asocial behavior. To care for the overt cases of mental illness (or "insanity," to use the legal term), many states have made systematic arrangements as adequate as the financial resources and the level of public opinion allow; other states have left the care of these patients to county organizations, while in still other states no definite plan of provision for the mentally ill has been formulated.

As Dr. Thomas Salmon, the first medical director of the National Committee for Mental Hygiene, said some years ago, "Every stage in the long and painful history of the care of the insane can be actually witnessed in some American community this afternoon." There are some public hospitals for the mentally afflicted which compare favorably with any general hospital; there are others where the patients are herded together under conditions which outrage the dignity of human nature. It is only yesterday as human affairs go, 1917 to be exact, that Salmon wrote his poignant account of the provision for the insane in a county poor farm: "In these cages, abandoned to filth and unbelievable misery, lie the insane poor of this pleasant, fertile, prosperous American county. . . . All of those distinctions which elsewhere govern the lives of human beings are merged in common degradation here." More recently (1937) in a careful survey of this field Deutsch has written: "There may still be found in the United States districts where the treatment of insane persons in jails and poorhouses is as inhuman as that which Dorothea Lynde Dix witnessed nearly a hundred years ago." These are not pleasant facts but have to be faced if we are making an honest study of social pathology.

Against this dark background of ignorance and neglect there stands out in sharp relief the enlightened attitude of many states where a central bureau or department, directed by competent experts, surveys the whole field, estimates the needs and the resources of the state, scrutinizes budgets, chooses carefully and supports loyally the physicians who direct the hospitals and their extramural activities. In the provision of hospitals for other forms of illness private philanthropy plays a preponderant rôle; but for mental illness there are in the whole country scarcely a dozen analogous hospitals supported by endowment or voluntary contributions.

The organization of a mental hospital and the rôle which under suitable direction it may play in the mental hygiene of a community were reviewed in the symposium. The efficiency of a mental hospital depends upon its personnel and upon its appropriations. Both these factors are intimately related to the life of the general community, to its economic life, its interests and code of values, its cultural and ethical standards, its political morality. The work of the state mental hospital is not an isolated function of medical science, practice and administration; it is a social function to which the physician can only contribute his individual endeavor. In seventeen states political considerations determine the appointment and tenure of office of medical superintendents and, in some instances, of all other persons employed in the state hospitals. Often physicians, *horresco referens*, without any suitable qualifications in the way of training or experience are appointed superintendents on account of their political services or personal contacts. The standard of medical care and research in a large number of hospitals is determined not by the status of contemporary medical science, but in part by predatory politicians trafficking in human misery.

The medical man may have therefore

to wage war against disease on two fronts; while carrying on his professional work to the best of his ability, not infrequently he has to reckon with the antagonism and disloyalty of those who should be his allies in the fight. He is apt at times to judge severely those who thus thwart and fail to support him. He may, however, in the light of his professional training, prefer to understand than to judge. With the help of the sociologist and the political scientist he may study the predatory politician and the conditions which produce him; he may study the legislator to find out what personal and social factors determine his attitude towards the claims of the mentally afflicted. In studying the electorate which has failed to play its part in correcting abuses or in backing improvements not only the political scientist, but also the cultural anthropologist, the sociologist, the economist and the educationist must come to the aid of the physician.

Even under favorable social and economic conditions the administrator of the mental hospital has a complex task, in carrying out each phase of which he finds himself acting within the definite limitations imposed by broader social factors. The professional training and outlook of his medical associates have been largely determined by the medical schools; the latter are deeply influenced by the contemporary currents of scientific and philosophic thought. The selection and training of nurses and other ancillary workers is affected by social attitudes and economic influences.

It is as one unit in this complicated social system that the physician with his own individual endowment and past conditioning, with his own professional equipment and philosophy of life makes his contribution to the study and treatment of the patients under his care. He faces the problems of diagnostic, curative, preventive work, tries to answer impatient demands for relief from an economic load, for some assurance that a devastating disease is at least under control.

In view of the wide-spread knowledge of the importance of mental illness as a medical and social problem, one would expect the community to respond here as it has responded to the challenge of other diseases, *e.g.*, of tuberculosis or cancer. One looks for a similar cooperation in the fight against mental illness, for well-equipped research institutes, for endowments commensurate with the complexity of the problem, for the interest of philanthropists, for the serious cooperation of the medical schools, for an adequate number of research fellowships, for the eager enlistment of well-trained medical graduates. With deep gratitude to those who have given serious support to the warfare on mental illness, one must still admit that the funds available for personnel and equipment are strikingly disproportionate to the magnitude of the task. Prejudice disappears slowly; surface appearances repel from close contact; dramatic success and quick returns can not be honestly promised; the difference between the problems of mental illness and those of bodily ailments is little realized. Medical science has gained its prestige from the study of the simpler functions of the human organism; the study of the more complex functions, those on which man's happiness, his efficiency and his human value depend, is frequently looked on askance by the medical scientist, and the younger generation is deeply influenced by the attitude of its teachers. So long as he is willing to work on the simpler functions of man with the precise methods adapted to their study the promising student will receive enthusiastic encouragement from his teachers, and can look forward to continued research under the most favorable conditions. When he proposes to study the human individual with special attention to his more complex functions, he will receive

encouragement from few of his teachers and must be prepared to prosecute research under much less favorable and more austere conditions.

Mental Illness

What is mental illness? What are those disorders to which reference has already been made? Can one state briefly their salient features, and give the layman an inkling of their significance?

The layman is inclined to think in terms of "the insane," and in that legal or administrative term with its residue of traditional associations all that is truly human and individual is apt to be lost sight of. The statutory endorsement by the court of the need of hospital treatment is a useful procedure in exceptional cases, but as a rule is a superfluous and disturbing procedure with which one would gladly dispense. Many patients with mental illness do not require hospital treatment. In many cases the symptoms do not betray their complex origin, and the patients complain of bodily symptoms, or of nervous symptoms of one type or another. In many cases the mental disturbance expresses itself in disturbing social behavior, and the patient is considered a delinquent. In other mild cases the individual is not considered to be sick at all, either by himself or by others, and his inner dispeace may only show itself in traits of character which we allow to pass in our neighbors without comment or analysis, hoping that they will be equally charitable towards us. The trait may even be capitalized and placed on the credit side of the account. A surgeon may be none the worse for a mild degree of misophobia (fear of dirt), which would be a serious neurosis in a clerical worker; a neurotic emphasis on precision, embarrassing to a grocer, may be an asset to a chemist.

It is well for us first of all to get rid of the traditional attitude which places such a wide gap between the so-called normal and the mentally disordered. Our normality consists in the ability to maintain a conventional surface so that our neighbors, perhaps we ourselves, do not have insight into the underlying forces at the basis of our moods, our interests, our behavior, our code of values, our attitude to the universe. Personality is etymologically derived from *persona*, the mask put on by the actor for the benefit of spectators. In mental disorders of a certain degree of severity the mask is broken and we see revealed the processes of human nature and are intuitively repelled.

We do well, however, as in other forms of sickness, in cases of ulcers, wounds, leaking hearts, faulty lungs, to control our intuitive reaction. When the physician interested in the sick person studies the offensive ulcer, the impaired circulation or respiration, and passes beneath the surface appearance he is plunged into a dynamic problem of the utmost complexity, of the greatest fascination. He finds revealed the subtle capacities of living material, dealing with stresses of the most varied description, and he becomes lost in the absorbing study of the forces involved. Pathologist and clinician alike are apt to talk in terms of esthetic rapture about the unusual beauty of material which to the uninitiated is displeasing and offensive. The intuitive reaction to the morbid and unusual is of brief duration in presence of curiosity as to the processes at work and of the eager hunt for general underlying principles.

If this be so in the face of bodily ailments, it is equally true with regard to disorders of the personality. Eager investigation replaces distaste and avoidance. With this new attitude in face of a mental patient, instead of seeing a human wreck, alien and unintelligible, separated from us by a deep abyss, we now see a particular instance of our common human nature dealing with the familiar issues of human life. The

patient comes very near to us; the story in many of its phases is our own.

Thus the desire to understand, the going beneath appearances, the tracing of the underlying forces of human nature help to develop an attitude to our patients and to our fellows which is in striking contrast with our intuitive reaction which we so seldom take pains to correct. A psychiatrist may occasionally have the opportunity to observe his own change of attitude towards an acquaintance. The latter considered as a social acquaintance may appear insupportable; as a patient with a human problem he becomes a fellow being of value who strikes a sympathetic note. If the psychiatrist could only maintain towards his acquaintances and colleagues the same attitude as towards his patients he would be a model of tolerance and patience. I suspect that a dinner party is rather complicated by the presence of a psychiatrist among the guests. He is suspected of looking on his fellow diners as he does on his patients. The suspicion is true. But if he does look on his fellow guests as he looks on his patients, it is because he looks on his patients as fellow mortals, as friends and colleagues of the same stuff as himself, facing the same human problems as himself, only making rather heavy weather of the actual life situation.

Coming back from one's acquaintances and oneself to the patients of a mental hospital—not such a violent jump, after all—one must first recognize the great diversity of conditions with which patients are afflicted. In discussing the ordinary run of bodily diseases we do not think in terms of some general "somatopathy," but in terms of the various special types of disease. Let us not blur the outlines of concrete experience in the present field by thinking in terms of a composite picture called "insanity." It may be necessary occasionally to use the general term insanity, but it is well to keep always in mind that one is dealing with human individuals in difficulty.

I may perhaps be allowed for the sake of this discussion, and with many qualifications, to divide mental illness in general into mental diseases and mental disorders. By *mental diseases* I mean those forms of mental illness where the physician finds evidence of underlying structural, toxic or nutritional damage to explain the disturbed behavior, thought or feeling of the patient. By *mental disorders* I mean conditions where no such unequivocal evidence exists.

Mental diseases in the above sense furnish the lesser half of the patients admitted to mental hospitals. In these patients the disordered behavior and thought are secondary to infections, to disorders of nutrition, to glandular imbalance, to disturbances of one or several organs or systems of the body. The problems of diagnosis, treatment and prevention in these cases are to be solved by the same methods as in the case of physical ailments in general.

Continuous progress has been made in our knowledge of these diseases, but the unsolved problems are many and await the eager mind, well trained and well equipped. The symposium emphasized many promising lines of investigation. Specially notable has been the increase of our knowledge about mental disease due to syphilis of the brain and to the abuse of alcohol. Here again one must refer to the responsibility which devolves upon the community. These forms of mental disease are preventable; together they represent a great economic loss and disrupt many homes.

Medical science has supplied the community with the requisite technical information in regard to mental disease of syphilitic or alcoholic origin, but the community shows little eagerness to utilize it. To utilize this information for the establishment of a more wholesome and efficient community life means a certain degree of enlightenment, a certain seriousness of purpose, a response to social needs, a willingness personally to

exert self-control and to limit self-gratification, an ability to free oneself from domination by group influence and familiar traditions. Prevention of these diseases is not a matter of enforced sanitation, but of continuous education. The medical profession has the responsibility for making as precise as possible the physiological results of alcoholism and of the consequent malnutrition and their influence upon the higher functions, and also the responsibility for studying the balance between the needs of man and the available resources for the satisfaction of these needs. The problem in the case of the alcoholic patient is in part to see what can be done to make life worth living for the individual. The solution depends in part upon social attitudes and organization, upon wages and upon housing, upon marital relations, upon religious beliefs and affiliations, upon the opportunities for recreation and self-expression. Similarly the problem of syphilis is not merely a bacteriological problem; it is one aspect of a major social and cultural problem.

A very different situation faces us when we take up the study of *mental disorders* in which we have so far no unequivocal evidence that there is a primary disturbance of any of the bodily systems. The physician may stand by an ancient dictum that all mental disorders are brain disorders, and hope that some day in the distant future the more thorough physical, chemical and physiological study of the brain will explain the attitude of man towards the universe and towards the demands of his social life. A more sound attitude is to study accurately the facts of human life and, while utilizing all that the biochemist and the neurophysiologist can teach us of underlying mechanisms, to keep in mind that these activities go on as the partial activities of living people, of people with warm emotions, vacillating purposes, partial insight. There is no *à priori* reason why we should discard the familiar facts of our personal experience and of our daily observations. We may of course for the purposes of physiological study provisionally discard these aspects of the living individual. In so far as we do discard them we are studying abstract processes, not the human individual who has a personality as well as a digestion.

The physiologist has contributed much to our knowledge of the emotional life. He has revealed to us by his ingenious experimental investigations the detailed processes of highly adaptive nature which form part of an emotional experience. The fact of the emotional experience, however, remains an equally solid datum of experience. The rôle which emotional factors play in the interplay of forces in the human personality has also to be studied. If we are interested in human nature and in interpersonal relationships we shall still have to use the term emotion, but that term will include all that the physiologist has taught us. He has enriched the meaning of the terms we use, deepened our insight into the workings of human nature, revealed to us details of the human organism hitherto unknown or obscure; he has thrown light on the symptoms of our patients, given help in their treatment.

In *mental disorders,* as above defined for the purpose of this paper, the constitutional vulnerability of the patient plays a rôle, but the influence of the environment must not be neglected. From infancy the environment begins to place its stamp upon the individual; throughout his life it makes continuous demands upon him. The study of an individual, which ignores his organic connection with the group, is the study of an abstraction. His childhood behavior is behavior in the special atmosphere of the home and of the school, and his personal development goes on as part of the development of a series of interpersonal relationships. In later life we see him in his occupational

setting, in the setting of the economic system, in a social system in which racial, religious and caste influences play upon him, enter into and are reacted to by his personality. It is in this complicated dynamic system that the individual lives his life.

We have already referred to contributions made by the sociologist, the economist, the cultural anthropologist. The psychiatrist in dealing with his individual patient is deeply indebted to these scientific colleagues, he has woven their contributions into the texture of his thought, enriched the connotation of his terms with the material they have supplied. His own special field, however, remains that of the study and care of the human individual in difficulty; the personality of the individual is the focus of his interest, and the human personality can neither be resolved into a physiological system nor dissolved in a system of interpersonal relationships.

Four Patients

So the physician, enriched and stimulated by workers in many fields, comes to his task, to the study of the human personality, of its needs and its difficulties and of the resources at its disposal. To illustrate these difficulties I offer a few fragmentary observations. I choose them from the more severe types of mental disorder and do this for the following reason. There is a growing recognition in the medical profession that the patient himself, the total organism, the human individual with all his personal difficulties, requires the same systematic study as the various organs and systems of the individual. There is, however, a tendency to give rather exclusive attention to the minor disorders, those disorders which do not estrange the patient from his fellows and from his physician, disorders which can be studied under the familiar conditions of medical observation. Granted that this is a very important field of medical work, which yields a rich harvest, there is a certain danger that this more elegant branch of psychiatry may be cultivated to the neglect of a psychiatry which faces the crudities of the more severe disorders, which have to be studied under the conditions which the disorders themselves allow. I can not forget the appeal of that half million of our fellow beings in mental hospitals whose crying needs are often so sadly ignored by the community and so inadequately met by the medical profession.

A childless Jewess, middle-aged, in poor economic circumstances, distresses her husband, her neighbors and a physician by fantastic stories; she claims that years ago she had a child, several children, and she runs around the neighborhood seeking to identify her imaginary first-born, now a lad in his teens. She later claims to be a person of high descent.

Behavior and beliefs pathetically incongruous with the actual facts; not to be explained in terms of tissue disorders, but in terms of individual human nature desperately striving to attain some sort of equilibrium in the face of unassuaged longings and prolonged deprivations. When life in its stark reality is no longer tolerable, man has still the resource of phantasy and of belief. The needs of the average individual may be adequately met by those beliefs which are common to the group, a cultural heritage, the product of a slow evolution. In face of her special needs this childless woman reached out for individual beliefs, which, however, could not be reconciled with the conditions of community life. Her personal inability to maintain her mental balance must be studied in its social setting. One must pay due attention to the family influences in her childhood, the social forces which conditioned her sex life, the racial attitude towards sterility, the limitations of recreation, friendly intercourse, supporting beliefs, the pres-

sure of economic circumstances. Each factor takes us beyond the isolated individual, indicates topics for research, suggests possibilities of melioristic social procedures.

A skilled craftsman invented some very ingenious toys which might be used as fire-lighters, also in his own words as "agents of the social revolution." The police found his room full of chemicals useful in the manufacture of explosives; also some pretentious manuscripts dealing with the difficulties of matrimony. An ambitious lad somewhat hard of hearing, he had been frustrated in his desire for an education; he had compensated by discursive reading and by the use of high-sounding words. Ungainly and unattractive to the other sex, he had learned to dance, hired his partners; in dancing he made up for lack of grace by rapidity and endurance. His unassuaged craving for personal distinction had led to pretentious authorship and to the idea of gaining prestige through the value of his inventions to a potential social revolution.

The many valuable assets in this man's endowment had found little encouragement at home or in his social environment. His history may throw light on the development of many a revolutionary leader. The economist and the historian may help us to compare the cost of a constructive program of mental hygiene with the expense in blood and treasure of one ill-balanced revolutionary leader.

In a mental hospital a young woman was much irritated by the nurses when they raised her shoulders in her bath; she talked with envy of Henry Ford. She had been brought up in a home of discord; her ambitions had been frustrated. Her great preoccupation was peace; she envied Mr. Ford not for his wealth itself, but because it enabled him to send a peace ship to Europe; the irritation with the nurses was due to their rumpling her wings, she was "the dove of peace."

Another young woman of prudish and reserved nature complained that people were taking an undue personal interest in her; they wanted to make her into Cleopatra, Helen of Troy, a savage woman, various film stars of considerable notoriety, a statue of liberty; she had been our Lord on the cross. In her curious utterances the conflict between fundamental cravings and cultural restrictions found expression; the mental disorder seemed to represent the disorganized continuation of an inner conflict which had given her life its special stamp.

I have offered these fragmentary illustrations of human difficulties to give some representation in my discussion to the human individual. I have tried to bring home to the reader the fact that beneath utterances that are fantastic and unreasonable, and conduct that is inappropriate and perhaps offensive, there may lie the familiar conflicts of human nature.

On Beliefs

Among the problems frequently presented by patients is the problem of their unusual beliefs, and with them the physician must deal, however poorly equipped for the task he may feel. The beliefs are facts of observation, they are special aspects of the activity of the human personality, of the human organism adequately conceived. It may therefore be permissible to make a few remarks on this topic from the point of view of the physician.

Belief plays an important part in the lives of many patients, it plays an important part in the life of the ordinary man, it plays a part in the life of the man behind the microscope and the test-tube. Science takes its origin from human curiosity; belief takes its origin from human needs. It is one of the biological qualities of man that he seeks to know what things are, how they work and what is their significance or value. Science tells him with increasing minuteness of detail and with

expanding breadth of vision how things work and the nature of sequences. The scientist as scientist can give no hint of the significance of the total world of experience as conceived under the categories of his science. He, too, requires something that goes beyond his science. He is not a mere spectator of a cosmic process; he is a dynamic element in the total system. He has to play his part in the game, he too has to take risks, to wed a belief, to take it for better or for worse. The marriage of course may not be celebrated openly, may be kept secret, even denied. The man in the street has a naïve belief in the significance of things. He is not satisfied with some colorless system, the mere product of observation and intellectual elaboration. The world for him is neither the "ghastly ballet of bloodless categories" of the Hegelian philosopher nor a meaningless dance of buzzing electrons. It is a system permeated with spiritual forces or values.

The cultural anthropologist and the philosopher have much to tell us about belief and its varied expression through history, under different climes and in different races. The physician has to deal with it in his own crude way as a biological phenomenon in the setting of the life of the individual patient. He has to consider its rôle in favoring or disturbing the internal equilibrium of the personality and the relation of the individual to the cultural group in which he lives. He is interested in its genesis in the individual case; he studies its adaptive value. He may consider what resources there are in the individual for attaining a more wholesome system of beliefs, and what resources there are in the community for bringing, through the medium of beliefs, comfort and stability to the individual. Under favorable circumstances when life is going smoothly, the individual human being may reject the need of any special system of beliefs; he may claim that in the face of difficulties the only sound response is to put forth effort and modify the actual circumstances. Even the positivist philosopher, however, in the face of catastrophic circumstances, which on account of factors intrinsic or extrinsic can not be modified—in the face of bereavement, of crippling and incurable disease, intolerable social or economic situations—may only be enabled to carry on by the resurrection of discarded religious beliefs.

Man does not live by bread alone; spiritual vitamins may be as essential to the welfare of the human organism as those other vitamins at present so assiduously advertised. We must not confuse the living belief with the external wrapping of dogma, creed, ritual and institution. The latter may divide and destroy, but the living belief in the significance of this world and the individual life has to be looked on as a powerful force that binds men close together. There is a certain unity of belief, as there is a unity of science.

On Conflicts within the Personality

The reference to the case of the childless Jewish woman has taken us far afield, and suggested some remarks on beliefs. The prudish young woman may tempt us to make some comments on conflicts within the human personality. She claimed that other people were thrusting on her the rôle of Helen of Troy and of other notorious or exhibitionistic characters; she disclaimed any such personal desires. Murder will out; in our own dreams, and in the symptoms of nervous and mental patients, hidden desires, repressed memories, unacknowledged fears find disguised expression. The young woman unsuccessful in maintaining the repression of sexual preoccupations could at least disclaim personal responsibility; "they," unspecified outsiders, were responsible for the threat to her character. She exemplified the mechanisms of re-

pression and projection by means of which we remain blind to important dynamic factors in our own nature, while their potent influence distorts our picture of the outside world. Here again the cultural environment enters into the equation. The young woman's blindness to her own sexual urge was determined by the atmosphere in which she had been brought up, was the product of influences unconsciously and consciously applied since infancy. In any constructive program of mental hygiene one must consider by what methods and procedures children may be prepared most efficiently to meet in a wholesome way the task of sexual adaptation, and what personnel and centers of influence are available for this purpose. The task is one which has not yet been faced, either by the community at large or by the medical profession, in an enlightened and unembarrassed way.

Life is a continual succession of decisions between conflicting tendencies. These conflicts are the special problem of mental hygiene; abnormal behavior, moods and beliefs are to a large extent the expression of conflicts unadjusted or unhealthily compromised. One can not both eat one's cake and have it. There is conflict between the various appetites. The juvenile in us conflicts with the grown-up, the egoistic with the altruistic, the imaginative with the realistic, one loyalty with another. As the individual matures, his hierarchy of values becomes more or less established, and decisions tend to be made according to this hierarchy and can to a certain extent be predicted; the more immature, the crude, the egoistic tend to be repressed under the pressure of the social code. Repressed trends do not necessarily atrophy and disappear, they may continue to lead a subterranean life beneath a conventional surface, they are liable to manifest their influence in traits of personality, in special interests, in our system of beliefs and code of values, in symptoms of mental and nervous disorder. The practical task of the psychiatrist is to help the patient towards a sound and sane balance between conflicting trends.

On Clothes

The above remarks have an important bearing on the scientific study of man as well as on the treatment of various disorders. The self-revelation which occurs in some mental disorders, and is achieved in others under treatment with effort and pain, offers a unique opportunity for the study of human nature, stripped of its customary coverings. To see man and his institutions in their stark reality is a rare acquisition. Professor Teufelsdröckh, whose mental twist led him to picture the most imposing court ceremonies with not a shirt on the participants, admitted that human imagination balked at figuring "a naked Duke of Windlestraw addressing a naked House of Lords."

Some persons might be aghast at a Who's Who in which the real individual appeared, stripped of his honors, degrees, official accomplishments and publications. This latter is the individual as seen in the consultation room. The physician therefore is able to furnish to our scientific knowledge of man a material which is unique, in which the needs, the resources, the mechanisms of the human personality stand out with unusual clearness. Some may refuse the term science to this body of knowledge acquired in the consulting room. This refusal is somewhat doctrinaire, but one must admit that the knowledge is gained under special circumstances and is difficult to formulate. The atmosphere of the consulting room is not the serene atmosphere of impersonal objective observation; it is an atmosphere charged with personal forces. One human being in distress appeals for help, another responds to this appeal of his fellow; a most unfortunate situation from the point of view of scien-

tific observation. The compensation lies in the fact that in the professional situation, in the face of issues of life and death, complete honesty may be at last attained.

On Methods

A difficulty with the material is that there are so many variables; systems can not be separated, concepts are difficult to define, are seldom scientifically pure. Instruments of precision appropriate to the most important factors are not available. One might also claim that experimental procedure is rarely applicable. In a certain sense this is true because the investigator dare not experiment with the fundamental issues of life. In another sense our patients present a unique experimental material. They are human beings with whom nature has carried out the most drastic experiments, acute and chronic. The investigator, however, has to wait until nature chooses to make these experiments; he can not determine their conditions; he can not rapidly accumulate material; he has to wait patiently and utilize eagerly the material which nature supplies, alas, too lavishly.

In the absence of the strict experimental method the investigator resorts to the statistical method, but here the large number of variables, the difficulty of defining terms and of precise measurement, the intimate relationship between the individual and the social group impose strict limits. He is, therefore, thrown back upon the biographical method. His task is very largely that of carrying out biographical studies with the utmost precision which the material allows. The biographical method is not unknown in other fields of science; biographical studies of the developing ovum and of various tissue cells have their own value, even when not reinforced by the experimental method. The biographical study of a tribe or of a nation may have to proceed without the help of experiment. The scientific biographical study of human nature is not to be identified with ordinary biography which seldom proceeds far beneath the surface, which is bound by conventional discretion with its reserves and reticences, which uses concepts with little precision. The biographical study of the human individual in the setting of the professional relationship discards convention, discretion, reticence. The terms which are used, although sometimes familiar and even colloquial, contain implicitly a reference to all that the basic medical sciences have taught us. The biography aims to present the real individual as he actually is and not to make him interesting in his appearance on the stage of history.

The Psychiatric Contribution to Our Knowledge of Man

The material so far accumulated is of value. The principles outlined in the light of this material may be looked upon as lacking precision; as first approximations they have great practical importance. It is dangerous to prefer very precise knowledge about unimportant detail to less precise knowledge about important issues. To avoid misconception one must of course emphasize the fact that no one can foretell when knowledge which at present appears of merely academic interest may become of great practical importance.

The physician, while engaged primarily in practical tasks, has as investigator been enabled to offer to his fellow scientists, studying man in his individual constitution and in his group relations, material which may with profit be incorporated into their concept of man. The physician has had to deal with the living individual; man of the other scientific disciplines is an abstraction or schema.

Man of the physiological laboratory is a most ingenious mechanism but lacks a soul. Man of the psychological laboratory is a highly respectable fellow, carrying out his simple tasks with docility, but

living a sheltered life, exposed to no human emergencies. Economic man, perhaps already extinct, was a curious fellow, bloodless and unemotional, moved by very few springs. As for the man of history, it was difficult to see him through his various trappings, his titles, his official exploits and the mendacity of his chroniclers. The data derived from the study of suffering man, neurotic and psychotic, may not only enrich the concept of man but may bring to special economic, sociological and cultural problems suggestions of theoretical and practical value.

The Needs of Man

In dealing with the needs and difficulties of his patients the physician finds that certain trends or cravings or needs recur with special frequency. The appetites claim their rights, pleasure is a directing influence, the sexual urge is of outstanding importance; man craves fellowship, friendship, affection, love; he craves a certain status or recognition from the group, a feeling of personal value, he suffers from a feeling of inferiority; he needs some reasonable opportunity for self-assertion, for the exertion of power and the expression of his individual skills and interests; he tends to see some orderly sequence in the flow of events; he tends to see the world as a system of values and his individual life as significant.

The Social Resources

In view of these fundamental human trends and cravings it is important to scrutinize our actual social organization and cultural atmosphere, to see how far these cravings can be satisfied and what difficulties stand in the way. One would like to see a thorough-going and systematic research into the organization of the home and of the school, of the factory, the store and the office, into the opportunities available in urban and rural communities for recreational and social activities, for self-expression and self-development in crafts and in intellectual and esthetic pursuits, and into the cultural codes and beliefs which permeate community life and give to the individual life its special significance.

The Next Step

The search for increase of knowledge and the practical application of existing knowledge to the demands of life are mutually profitable and stimulating. The limitation of existing knowledge is no excuse for failing to apply the knowledge already available. Meteorology may be a very incomplete science, but one does not on that account refuse to take a prophylactic umbrella. The progress of mental hygiene will depend on further research, but also on well-organized effort to disseminate existing knowledge and to embody it in actual procedures. The knowledge already available would if applied transform the lives of countless individuals and leaven the life of the community.

The field of mental hygiene is so extensive, so complicated, so interwoven with social and cultural issues that the cautious refuse its challenge, hesitate to engage their energies and their funds. Accustomed to simpler problems and procedures, which yield comparatively rapid and demonstrable results, they are impatient with results which depend in part on processes of social education and evolution, so much slower than measures of sanitation.

The challenge remains; fortunately the resources for meeting that challenge are already considerable. The medical profession is beginning to realize its special responsibility for the increase and dissemination of knowledge in this special field. There is a stirring in the medical schools which, it is hoped, will soon place this medico-social problem in its proper

place in the medical curriculum and in programs of research.

As for the systematic and organized application on a nation-wide basis of the knowledge already available experienced leadership is at hand. The National Committee for Mental Hygiene has for almost thirty years not only carried on an important series of surveys, but has throughout the whole country been intimately associated with the organization of regional activities. Its experience offers an invaluable basis for nation-wide plans.

The federal Public Health Service has recognized the place which mental health plays in the general field of public health, and can put its unequalled resources behind any constructive scheme. Several large Foundations have shown their interest in the field of mental hygiene, and have generously contributed to specific projects.

In several states there are competent state departments of mental health, supervising an efficient system of hospitals, each one of which is a regional center of mental hygiene, its activity radiating into the life of the community, integrated with many other social activities. In various states are scattered child guidance and other community clinics, working models capable of adaptation to communities of varied resources. The school system and the teachers' colleges are strategic centers of the greatest value. The executives in many large industrial and commercial organizations are deeply interested in mental hygiene. Beneath the hard-headed exterior of the president of a large financial or industrial concern there may lurk a sentimental humanitarian, just as the exterior of a modern scientist may conceal a medieval scholastic. Throughout the country there are countless enlightened and public-spirited men, with an unusual tradition of philanthropic support for humanitarian activities.

The resources for meeting the challenge of mental hygiene are by no means negligible; for their utilization one may need additional enlightenment, inspiration, organization and direction.

NATURAL HISTORY OF SANTA CATALINA ISLAND[1]

By Dr. T. D. A. COCKERELL
PROFESSOR EMERITUS OF ZOOLOGY, UNIVERSITY OF COLORADO

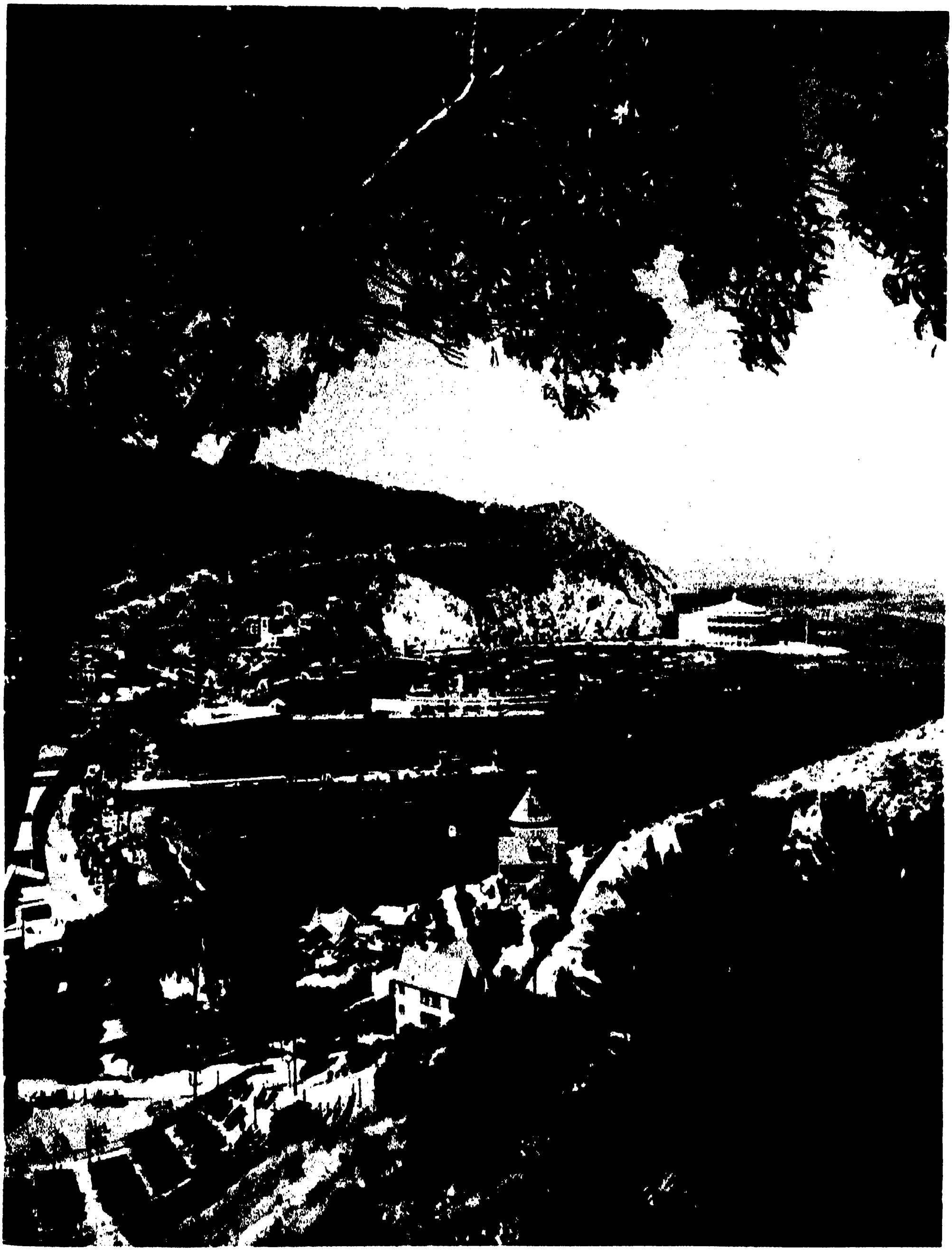
To any naturalist, the life of islands has a peculiar fascination. Here he may study the effects of the environment on an isolated fauna and flora, or may find, still surviving, types which have died out as the result of severe competition on the mainland.

We all remember how Darwin's visit to the Galapagos Islands caused his keen mind to reason about the origin of the insular birds and reptiles, and was the means of leading him to develop a theory of evolution. If there is any one now living who doubts evolution, and is at the same time willing to consider the evidence, the life on islands may be recommended to his consideration. He will see how remote islands have apparently been populated in various accidental ways, at long intervals of time, and how the colonists have multiplied and divided into numerous species, as shown by the snails, beetles and other invertebrates of many islands in the Pacific Ocean. These swarms of insular species, if one may so call them, are very conspicuous in the tropical Hawaiian Islands, but no less so in islands far to the south, such as Rapa, where the climate is warm temperate. In spite of the complexity of the subject, the main outlines are fairly evident, and should be convincing to those who will impartially study the evidence.

Wallace, in his classic book, "Island Life," described the different types of islands; those called continental, which were once part of a mainland, and those called oceanic, which rose out of the depths of the sea and were islands from the beginning. This classification can usually be made by a study of the fauna. The oceanic islands, for instance, have no native frogs or salamanders, or mammals other than possibly some bats.

My wife and I have at different times visited many islands, all different and deserving intensive study. As early as 1879 I went to Madeira, and again long after to Madeira and Porto Santo. These islands, out in the Atlantic east of North Africa, are especially remarkable for the extraordinary number and variety of land snails. At one time, I was curator of the museum at Kingston, Jamaica, a beautiful tropical island celebrated for its ferns and snails, its birds and butterflies. Not very many years ago, we visited New Caledonia, a large island in the South Pacific, which has an extraordinary flora with many peculiar plants, but a relatively poor insect fauna. The Hawaiian Islands, Samoa and Fiji have given us some undescribed forms of insects or snails as the result of brief visits. And finally, I must not forget the British Islands, where I was born and grew up. Wholly continental in type, they nevertheless have some special forms of life, even mammals, birds and fishes not known from elsewhere. It is difficult for a visitor to appreciate all these diversities, unless he has made a special study of the subject and has read the appropriate literature. It is indeed difficult for a resident, if he has not made comparisons and studied details. In quite recent years, rather numerous special (endemic) races of birds and mammals

[1] The flower pictures illustrating the article are by Mrs. Eugene M. Smith of Avalon. All the others have been kindly supplied by the publicity department of the Catalina Island Company.



VIEW OF AVALON,

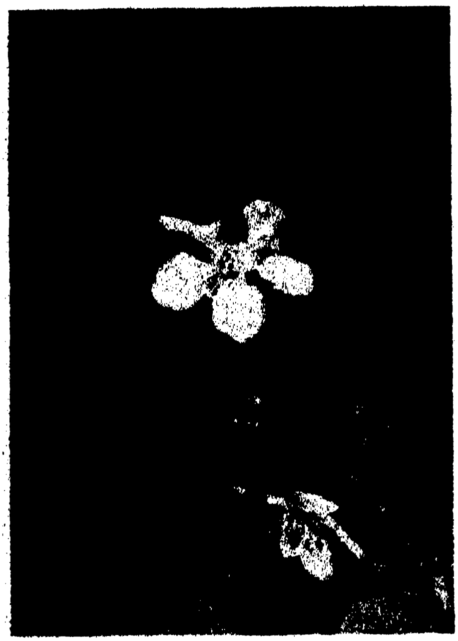
THE ONLY TOWN ON ANY OF THE ISLANDS. IT IS A FAMOUS TOURIST RESORT, AND IS GREATLY OVERCROWDED IN THE HEIGHT OF THE SEASON, BUT DURING THE GREATER PART OF THE YEAR IT IS A VERY PLEASANT PLACE TO STAY, AND ONE MEETS MANY INTERESTING PEOPLE.

TREE POPPY,
Dendromecon harfordii OF KELLOGG; ONE OF THE MOST BEAUTIFUL ISLAND ENDEMICS. THE NAME OF THE GENUS MEANS TREE-POPPY IN GREEK. THE PLANT WAS DISCOVERED BY W. G. W. HARFORD ON SANTA ROSA ISLAND IN 1872, AND DESCRIBED IN 1873. THE SANTA CATALINA FORM HAS SOME DISTINCTIVE CHARACTERS, AND WAS CALLED *Dendromecon arborea* BY GREENE, MATERIAL HAVING BEEN COLLECTED IN 1896 BY MRS. TRASK. IT PROBABLY SHOULD STAND AS *D. harfordii arborea*. THESE BEAUTIFUL POPPIES ARE VARIABLE, AND IN NEED OF FURTHER STUDY. THE WHOLE GENUS IS CONFINED TO THE PACIFIC COAST REGION OF TEMPERATE NORTH AMERICA.

have been described from the British Islands, in spite of the long period before, when these creatures were familiar to resident zoologists, but considered to have no special peculiarities. It may be argued that when the differences are so slight as to almost escape observation, it is not worth while to distinguish them, but the biologist sees here the beginnings of the evolutionary process, and finds the very material he needs for the establishment of the theory.

When, in other cases, the insular endemics are so distinct as to strike the eye of any casual observer, it is not evident, without additional information, whether these creatures are really special to the islands or not. Thus we need brief illustrated guides to all the groups of islands, explaining, so far as may be, the significance of what may be seen.

My past interest in this subject makes it natural that I should be attracted by the problems presented by the eight islands off the coast of California. For the most part in plain sight from the mainland, they nevertheless have an extraordinary number of endemics, that is, forms restricted to the islands, found nowhere else. A former connection with the mainland is indicated by the presence of salamanders, and on the northern islands by the remains of an extinct



CROSSOSOMA CALIFORNICUM
(OR *C. californica*, IF WE FOLLOW THE LATIN RULE THAT ALL TREES ARE FEMININE). THIS TYPIFIES A DISTINCT FAMILY OF PLANTS, AS DESCRIBED IN THIS PAPER. IT IS A SMALL TREE, REMARKABLE FOR THE DELICATE BEAUTY OF ITS WHITE FLOWERS, AND THE CURIOUS FINGER-LIKE PODS. PEOPLE IN STA. CATALINA CALL IT WILD APPLE, BUT THE NAME IS INAPPROPRIATE. FINGER-TREE, FROM THE APPEARANCE OF THE FRUITS, WOULD BE BETTER.

species of elephant or mammoth, the *Archidiskodon exilis* of Stock and Furlong. No amphibia, such as the salamanders, can cross the ocean, and it can not well be doubted that the elephants came on dry land. Thus connection with the mainland, at some remote period, must have occurred. Geologists have postulated that, as late as Miocene times at least (between about 17 and 37 million years ago), there existed a large land area, including all the present islands, which were then parts of mountain ranges. This land has been called Catalinia, and it is supposed that it included San Pedro Hill, familiar to mainland Californians, which looks very much like another island when seen from Santa Catalina. Long isolation is further suggested by a very distinct kind of jay

VIOLA PEDUNCULATA,
THE YELLOW VIOLET OR PANSY COMMON ON GRASSY SLOPES. IT IS A COMMON SPECIES OF THE MAINLAND. NEAR THE WRIGLEY HOUSE ON THE CLIFF ABOVE AVALON I FOUND SOME WITH VERY LARGE FLOWERS, AND WONDERED WHETHER THERE COULD BE AN ISLAND RACE. BUT LATER I FOUND MANY PLANTS WHICH APPEARED TO DIFFER IN NO RESPECT FROM THOSE I HAD SEEN ON THE MAINLAND.

COREOPSIS GIGANTEA
OF KELLOGG, GROWING ON THE CLIFFS AND SLOPES AT AVALON. FLOWERS YELLOW, AND STEMS EXTRAORDINARILY STOUT, LIKE A SMALL TREE-TRUNK. I HOPED TO FIND A SPECIAL BEE VISITING THIS PLANT, BUT NOTHING OF THE SORT WAS OBTAINED. THE GIANT COREOPSIS IS ALSO FOUND ON THE COAST OF THE MAINLAND, AND JEPSON SAYS IT MAY ATTAIN A HEIGHT OF SIX FEET.

(*Aphelocoma insularis*) confined to Santa Cruz Island, where it is common. Assuming that this bird acquired its distinctive features after the island became separated from the mainland, we have some indication of the rate of its evolutionary development in the length of time that has passed during the last period of the latest geologic era. That is, the evolution of the jay must be supposed to have occurred during a part of the Pleistocene.

The question arises as to whether this former land area, Catalinia, extended down to Guadalupe Island, which is 135 miles southwest from Point San Antonio, Lower California. Guadalupe has no less than eleven of the plants which are otherwise confined to the California islands, and three of the snails, but there are no

RHUS INTEGRIFOLIA,
A VERY COMMON SHRUB WITH PINKISH FLOWERS, KNOWN AS LEMONADEBERRY. IT IS REALLY A KIND OF SUMAC. ON SAN MIGUEL ISLAND IT USED TO ABOUND, BUT HAS NOW DISAPPEARED AS A RESULT OF OVER-GRAZING. THE GNARLED TRUNKS ARE STILL TO BE FOUND IN ABUNDANCE, AND ARE USED AS FUEL. ON PRINCESS ISLAND, OFF SAN MIGUEL, THIS SHRUB STILL SURVIVES.

land mammals. A bottle placed in the sea at Port San Luis, California, was recovered at Guadalupe Island 38 days later, showing that the currents are favorable. It had traveled about 400 miles, with an average speed of about 10 miles a day. Thus any floating object would reach Guadalupe Island quite easily, even under present conditions. In a paper to be published later, I have reviewed the Guadalupe problem, and contrary to my previous bias, conclude that the island is oceanic—that is, had no mainland connections. Its long isolation is indicated by the existence there of no less than nine kinds of endemic birds, seven of them regarded as distinct species. Three are unfortunately probably extinct, owing to the obnoxious behavior of man. This conclusion tends to sharpen our wits for the detection of means of transport across the sea, and requires observations which are often hard or impossible to make, the immigrants arriving so rarely, at long intervals of time.

Santa Catalina, about twenty miles south from San Pedro, seems to have subsided in the comparatively recent past, according to R. D. Reed.[2] The island is 18½ miles long, with a maximum width of 7 miles. The highest peak is 2,109 feet above sea level. The island is extremely rugged, with rocky slopes which, with their piles of ancient débris, indicate long-continued erosion. The recent heavy rains have resulted in many land-slides, blocking the roads, but these have been largely due to the operations of men, making steep banks when building roads.

On landing at Avalon, it is not necessary to go far to find some of the most interesting endemics. Flying around the Birdsfoot Trefoil (*Lotus*) one sees little brown butterflies, the hind wings with thread-like tails. These belong to the species *Strymon avalona,* entirely confined to this island. The related mainland butterfly, *S. melinus,* is found on Santa Cruz Island, as shown by a specimen collected by John Garth, in the collection of Don Meadows. There is a very deep channel between Santa Catalina and the northern islands (the deepest part over 700 fathoms) and it must be a very long time since they were united. Certain kinds of butterflies, such as the Painted Lady (*Vanessa cardui*) readily cross arms of the ocean, and reach the islands from the continent. But with other species this seems not to occur. Many species common on the mainland do not exist on the islands, in some cases owing to unfavorable conditions, but in others apparently because they have not been able to cross the sea.

Turning to the left on leaving the steamer, we soon come to the high cliffs

[2] "Geology of California," 1933.

below the Wrigley house. Here I discovered under rocks, years ago, the endemic snail *Micrarionta rufocincta beatula*. It has a small shell, with the margin of the aperture greatly thickened. I recently found it at Pebbly Beach, living under stones with ants. On the face of the cliff are large plants with stems as thick as one's arm, thread-like leaves and bright yellow daisy-like flowers. This species is *Coreopsis gigantea,* very characteristic of the islands, but not peculiar to them or to Catalina, as Holder stated.

Along the road at the top of the cliff, and in many other places here and there, we find a shrub with beautiful white flowers, facing downward, rather suggesting apple blossoms. The fruits are very peculiar, with finger-like follicles, rather suggesting a peony, one to seven in a cluster from a single flower. Locally, the young people call it wild apple, but this is quite misleading; finger-plant would be descriptive but not elegant. It is a plant to be regarded with extraordinary interest, not only for its delicate beauty, but because, with another species in the deserts of the Southwest, it represents a distinct family of plants. Our Catalina species is also found on San Clemente and Guadalupe Islands, and may well have been an inhabitant of the old Catalinia. Its botanical name is *Crossosoma californicum,* and it was described by Nuttall nearly 90 years ago from material collected by the ornithologist, Dr. Wm. Gambel. Such instances raise the question why a family of plants should thus be confined to such a limited area. It can not be doubted that it is of great antiquity, and one must suppose that it formerly occupied a much larger territory, though this is not certain. Perhaps fossil remains will turn up later. The two existing species seem to get along well in their present habitats, and it will take close and patient study to determine why they are not more wide-spread. I watched the *Crossosoma* on Sta. Catalina in the hope of observing its insect visitors, but did not see anything.

About fifty years ago Wm. S. Lyon explored Santa Catalina for plants, and found the remarkable tree which Asa Gray, of Harvard University, set forth as a new genus, naming it *Lyonothamnus.* This genus is entirely confined to the islands, except that it exists in cultivation, as at Santa Barbara. The trees, about 30 feet high, occur on Santa Catalina in steep gulches, and the flowers, which I have not seen, are described as white and beautiful. The flowering time is in June. The popular name is ironwood, which is unsatisfactory, because it has also been used for quite a different plant. The nearest relatives are the Spiraeas, of the rose family.

Continuing along the road to the left, on the board-walk by the sea, we come to the little settlement known as Pebbly Beach, where the pottery works were established. Turning the corner by the stone quarry, we soon come to a place where we see alongside the road some tall plants with long spikes of dark-colored

THE ISLAND QUAIL

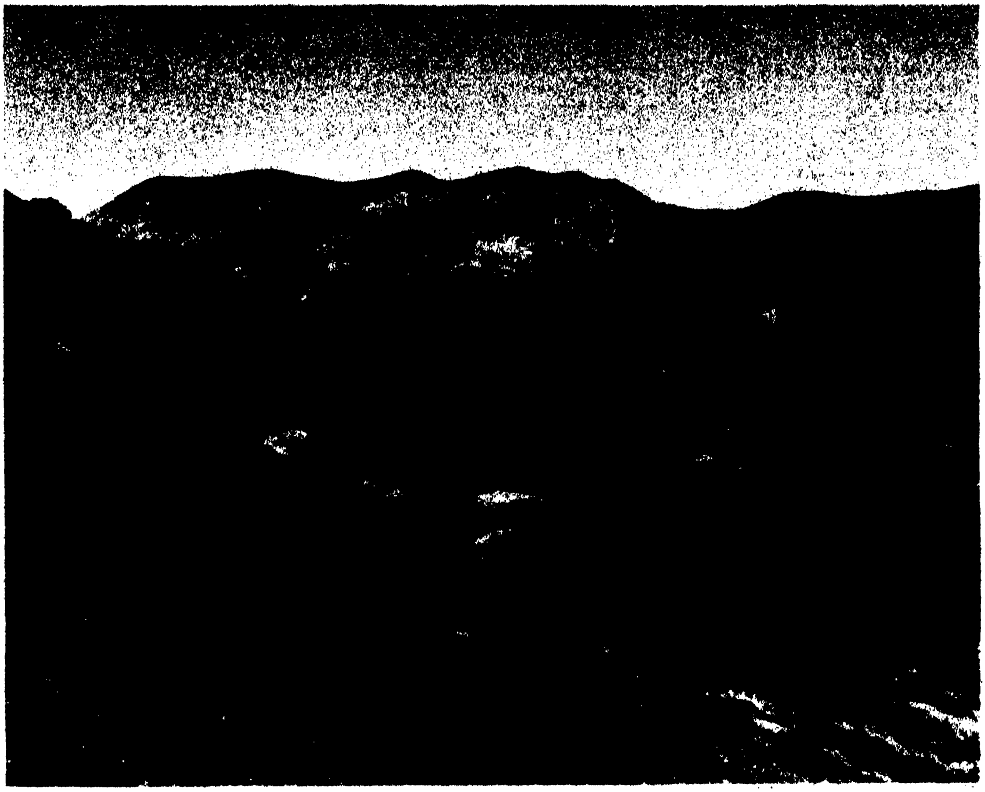
DESCRIBED BY DR. GRINNELL AS A DISTINCT SUBSPECIES, *Lophortyx californica Catalinensis.* IT IS ABOUT 9 PER CENT. LARGER THAN THE MAINLAND BIRD, AND SOMEWHAT DARKER. THE BILL IS HEAVIER, AND THE FEET STOUTER. IN 1895 GRINNELL THOUGHT THE STA. CATALINA QUAIL HAD BEEN INTRODUCED, BUT IN 1906 HE CONCLUDED THAT THIS WAS NOT THE CASE. QUAIL WERE KNOWN ON STA. CATALINA AT LEAST AS FAR BACK AS 1859.

PICTURE TAKEN FROM THE SUMMIT,
THE HIGHEST POINT ON THE ROAD ACROSS THE ISLAND. FROM THE HIGH LAND ON STA. CATALINA ONE MAY SEE THE CALIFORNIA COAST VERY DISTINCTLY IN ONE DIRECTION, AND ON THE OTHER SIDE THE ISLANDS OF SAN CLEMENTE AND SANTA BARBARA. A FEW BISON HAVE BEEN INTRODUCED ON STA. CATALINA, AND WE SAW THEM NEAR THE SUMMIT, GRAZING.

flowers, the whole spike with long, glandular, silvery hairs. This is the figwort, *Scrophularia villosa,* peculiar to Santa Catalina and San Clemente. It is visited by numerous bees, *Emphoropsis depressa,* gray insects which fly rapidly, going quickly from flower to flower. In many cases the flowers are dependent on certain visitors for cross-pollination, and these visitors depend on the flowers for food. When this phenomenon (called oligotropism) occurs, the plant and its bees must migrate together, if at all. Thus in Colorado the long-tongued bee *Melitoma* is associated with the wild bush morning-glory, and is common near Denver, where the plant occurs, but quite absent at Boulder, where the plant is lacking. Why the distribution of the plant should be thus limited, I do not know.

Ten miles from Avalon, we visit Middle Ranch, and there find a peculiar groundsel, *Senecio lyonii* of Gray (another discovery of W. S. Lyon), which has tufts of white, wool-like material in the axils of the leaves, giving it the appearance of being infested by mealybugs. This plant occurs on Santa Catalina and San Clemente, but also on the peninsula of Lower California.

One of the most beautiful island endemics is *Eriophyllum nevinii,* which grows on the face of the cliff at Avalon, near the casino. This is a composite plant with yellow flowers and dissected



CAPE CANYON

A TYPICAL VIEW OF AN INTERIOR VALLEY, WITH LOW-GROWING OAK TREES. WE VISITED SUCH A CANYON (BULLRUSH CANYON) NEAR MIDDLE RANCH, AND FOUND THERE SOME INTERESTING INSECTS AND PLANTS.

silvery leaves; it deserves a common name, and indeed two names have been suggested, but both belong properly to quite other plants. I propose that it be called Catalina Silver Lace.

As we go along the road, dark-colored ground-squirrels constantly run across from side to side; these are the endemic *Citellus beecheyi nesioticus,* described by Elliot in 1904. The island has three other mammals all its own, a small fox and two kinds of mice. The existence of so many races of mammals on continental islands is an indication of the relatively rapid evolution of these animals, although it is true that the differences observed are usually not very profound. Since divergence can occur in all sorts of characters, physiological or structural, it is necessary to remember that the amount of difference can not always be estimated from the superficial examination of preserved skins. It is probable, however, that the insular races of mammals would for the most part interbreed freely with their nearest relatives, were they not isolated.

Still more conspicuous than these mammals are the quails, which constitute a special race (*Lophortyx californicus catalinensis*) of the California quail. Dr. J. Grinnell, of the University of California, who distinguished it, states that it is about 9 per cent. larger than the mainland bird and has a darker color. There was a question whether the quail had been introduced by man; it is known at least as far back as 1859, and is now be-

LITTLE HARBOR, SHOWING THE CHARACTERISTIC SHORE-LINE OF THE WESTERN SIDE.

lieved to be a true native. The quail on San Clemente was introduced, and is the ordinary mainland bird.

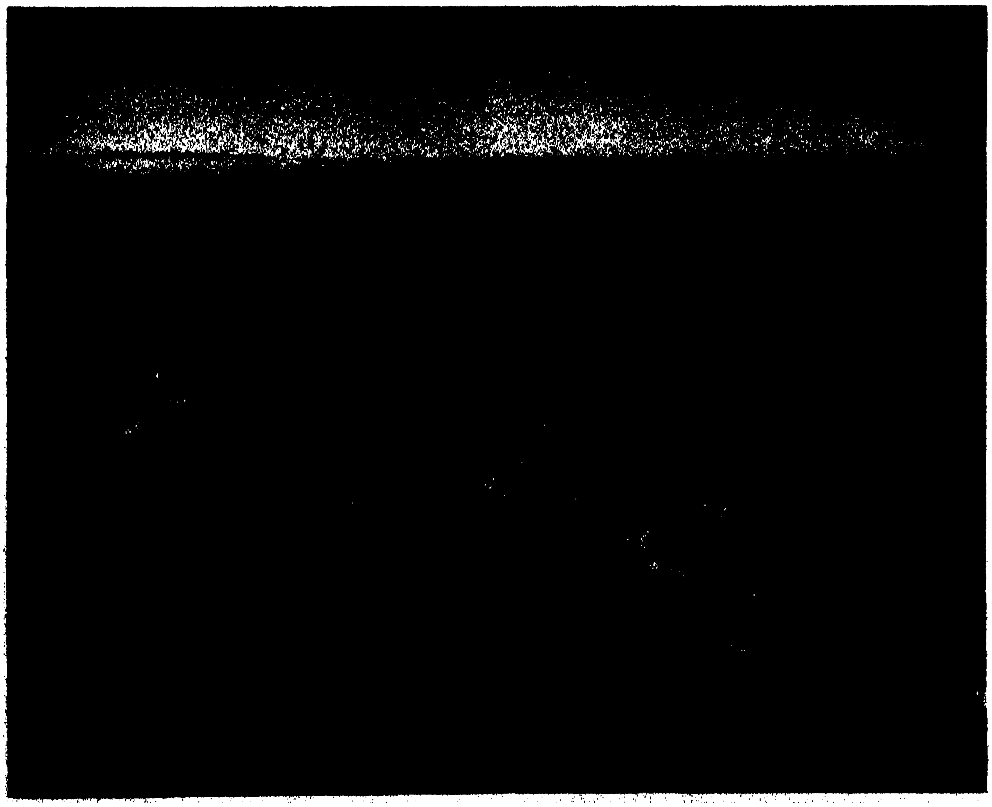
A very interesting case is that of the little humming-bird with reddish-brown tail, named *Selasphorus alleni sedentarius* by Grinnell. The mainland Allen humming-bird migrates to Mexico in the winter, but the island form, which Dr. Grinnell tells me occurs on Santa Catalina, San Clemente and Santa Cruz, does not leave. It is also larger, and differs in some details of coloration. The difference in the behavior of the humming-bird may be ascribed to the direct effect of the relatively uniform climate of the islands, with mild winters; or it may be due to a physiological peculiarity which has evolved on the islands and proved advantageous.

Mocking birds are abundant and resident. They are said to be lighter on the back than the mainland form, at least so far as concerns the birds of San Clemente, but no distinct race is recognized. A. B. Howell (1917) states that the life-cycle of the smaller birds on the southern islands is shifted a month or six weeks earlier than that of the corresponding mainland forms, the molt occurring earlier than on the mainland. I was interested to note that the large handsome bees (*Anthophora stanfordiana*), which visit the flowers of the loco weed (*Astragalus leucopsis*), on Santa Catalina are flying at the beginning of April, whereas Mr. Timberlake tells me they appear at Riverside in May.

I have in manuscript a revised list of the beetles of the islands, and find about 39 to be apparently endemic. These belong mainly to three families, and

especially to the Tenebrionidae, many members of which are large black ground beetles, unable to fly. The large number of endemic insects is of course a consequence of the numbers of species of these animals. Although there are many more endemic beetles than mammals, the island mammals are all more or less distinct, except the bats, whereas only a small proportion of the beetles is distinct. It is conceivable that in some cases endemic island insects may have reached the mainland, and so lost their endemic status. I have elsewhere given reasons for suspecting that this may be true of some of the plants. The smaller flying insects may be blown long distances by the wind. Thus A. C. Hardy and P. S. Milne (1937) report on insect drift over the North Sea. They obtained no less than 730 specimens, in some cases 120 to 150 miles from the English coast. Of all the island beetles, perhaps the most remarkable (because most distinct) is the *Eleodopsis subvestitus*, described by Blaisdell (1937). Nineteen specimens were collected on San Nicolas by J. R. Slevin in 1911; but they had an ordinary appearance, and were not for a long time recognized as peculiar. But Dr. Blaisdell, on recently studying them, found them so peculiar as to require the establishment of a new tribe, Eleodopsini.

The examples I have cited are only a few of the many rare or endemic plants and animals to be found on Santa Cata-



THE ISTHMUS,

THE NARROWEST PART OF THE ISLAND, WHERE MANY "SOUTH-SEA" PICTURES HAVE BEEN FILMED IN RECENT YEARS. THE ISLAND OF SAN CLEMENTE IS SEEN ON THE HORIZON. NOT FAR FROM THE ISTHMUS WAS THE HOME OF MRS. BLANCHE TRASK, WHO WAS LONG FAMOUS AS THE BOTANIST OF THE ISLANDS. FIVE OF THE ISLAND ENDEMIC PLANTS HAVE BEEN NAMED AFTER HER.

lina. No doubt the mammals, birds and flowering plants have all, or nearly all, been recorded; but among the insects there will be hundreds of additions to the fauna, when sufficient collections have been made and worked up. Mr. Don Meadows, of Long Beach, was a teacher in the high school at Avalon from 1927 to 1934, during which time he explored all parts of the island, collecting butterflies and moths. He has published a list (1936) of the Santa Catalina butterflies, 28 species. Of these, there is one endemic species, as mentioned above, and two forms of orange-tips have been recorded as endemic races.[3] The list of moths has not yet appeared, but I was recently permitted to examine the Meadows collection, and found over 170 species identified, and a good many others still to be determined.

A striking feature of the lepidopterous fauna is the absence of types common on the mainland. Thus the well-known butterfly *Euphydryas chalcedona* (the chalcedon checker-spot) is wholly absent, though its food plant is present. It exists on Santa Cruz Island, where it was collected by John Garth. Among the moths, the large silk-moths or Saturniidae are absent, and only four kinds of sphinx moths were taken.

In order to obtain true understanding of the life (biota) of Santa Catalina, it is necessary to consider both past and present, and to know both plants and animals, large and small. Such exhaustive knowledge is impossible for one individual, and the whole subject may appear too complex to be intelligible. Nevertheless, the broader features of the picture are readily appreciated, and can be understood by any intelligent person. The details are full of interest and lead us on to one discovery after another. Putting together what is already known, we have a large mass of ascertained facts, which can be arranged and compared. In the course of time, it may be possible to present the gist of all this in a book, which, if clearly written and well illustrated, will serve as a guide to those who would know something of the natural history of the island and a stimulus to those who would seek out the still unknown facts. In dealing with these matters, it is not sufficient to offer crude statistics, which may be misleading. I have in my possession (given to me by his son, Francis Darwin) an old manuscript of Charles Darwin's, in which the objections to statistical methods, without proper analysis, are well set forth. Darwin says: "If North America had no mammal identical with Europe, same way as South America has not, then the percentage system would not show that North America was incomparably closer allied in its mammifers than South America is." "It comes to this, that the percentage system takes no account of relationship of organisms, when all species differ. For instance, Galapagos *land* birds all different from South American, yet certainly closest alliance."

If these difficulties increase our perplexities and doubts, they also indicate opportunities for fruitful research, leading in some cases to results which could hardly have been anticipated.

[3] One of the latter was rejected by Mr. Meadows as not distinguishable, but he now thinks it may be accepted, though the characters are very slight.

BEHAVIOR AND SOCIAL RELATIONS OF FREE-RANGING PRIMATES

By Dr. C. R. CARPENTER

DEPARTMENT OF ANATOMY, COLLEGE OF PHYSICIANS AND SURGEONS, COLUMBIA UNIVERSITY, AND THE SCHOOL OF TROPICAL MEDICINE, SAN JUAN, PUERTO RICO

INVESTIGATORS interested in comparative studies of primate behavior have, during the past ten years, carried out a series of studies on selected types of primates in their native habitats. Henry W. Nissen did observational work on free-ranging chimpanzees in French Guinea,[1] and shortly afterwards Harold C. Bingham made a field study on the mountain gorilla in relation to its habitat in the Belgian Congo.[2] During the same period S. Zuckerman observed extensively the baboons of Monkey Hill in the London Zoological Garden and while collecting anatomical specimens, he did limited work on the free-ranging baboons in South Africa.[3]

Continuing the studies on free-ranging primates under the direction of Professor Robert M. Yerkes, of Yale, I spent the greater part of the time from 1931 to 1933 in studying the New World primates or platyrrhines, especially the howling monkeys (*Alouatta palliata*) on Barro Colorado Island in the Panama Canal Zone.[4] Extensive observations were also made on red spider monkeys (*Ateles geoffroyi* Kuhl) of northern Panama and Costa Rica,[5] on the capuchin monkey (*Cebus capucinus*) of Panama, on the squirrel monkey (*Saimira örstedii*) of northern Panama and on the Canal Zone marmoset (*Oedipomidas geoffroyi*).

These studies are part of a general program of field work on sub-human primates which has the stated objective of accumulating reliable and extensive data on a series of important, selected primate types living in their native habitats. This research work involves prolonged observations of all modalities of behavior, social relations, ecological relations and the use of every available means of getting accurate information on the life histories of the species selected for observation while they are living undisturbed in the environment which has given rise to the species.

Thus in the comparative studies of the behavior of monkeys and apes, a field in which there has been so much speculation, though it has been unduly neglected by scientists when its probable significance is considered, attempts are being made both in the field and in the laboratory to accumulate a sound factual body of information. It is hoped that this information on free-ranging animals will supplant the colorful tales of dramatic incidences told by sportsmen, hunters and travelers and embellished to make good adventure stories. The data may importantly supplement the sketchy and unreliable reports which have characterized the literature dealing with the life histories of man's closest living relatives in the mammalian series.

Professor Adolph H. Schultz, of the Medical School of the Johns Hopkins University, has for many years been making large collections of primate specimens, especially skulls and skeletons, in

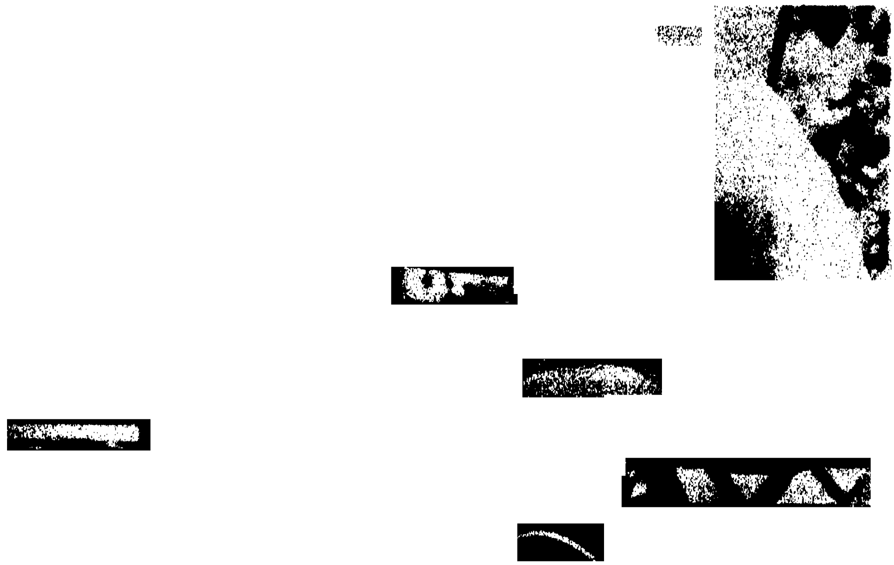
[1] H. W. Nissen, *Comp. Psychol. Monog.*, Vol. 8, No. 1, pp. vi–122, 1931.

[2] H. C. Bingham, *Carnegie Inst. Wash. Pub.*, No. 426, pp. 66, 1932.

[3] S. Zuckerman, London, Kegan Paul, Trench, Trubner and Co., Ltd., pp. 357, 1932.

[4] C. R. Carpenter, *Comp. Psychol. Monog.*, Vol. 10, pp. 1–168, 1934.

[5] C. R. Carpenter, *Jour. Mammal.*, Vol. 16, No. 3, pp. 171–180, 1935.



THE RECORDING APPARATUS FOR GIBBON CALLS.
THE EQUIPMENT CONSISTED OF A PRESTO UNIT, TWO BATTERIES AND A TRANSFORMER GENERATOR.

order to ascertain intraspecies variations and to make possible comparisons of a wide range of primate types. Professor Schultz has found it expedient from time to time to go into the native habitats of selected primate types in order to have adequate numbers of freshly shot specimens for statistically significant series. In addition, these collecting expeditions have yielded much relative to reproductive phenomena and embryological development.

The Asiatic Primate Expedition

A group of scientists returned to the United States, in September, 1938, after nine months in the field, having concluded another field study of a significant and little known primate anthropoid type; this time the gibbons (*Hylobatedae*) of Siam.

The Asiatic Primate Expedition was organized during 1936 by Mr. Harold J. Coolidge, Jr., Dr. Adolph H. Schultz and the writer. The expedition was sponsored by Harvard University, particularly the Museum of Comparative Zoology and the Peabody Museum, by Columbia University through the Council for Research in the Social Sciences, by the Johns Hopkins University, especially the Medical School, and by the Carnegie Foundation of Washington. The main objectives of the expedition were three: (1) Dr. Schultz, Mr. Coolidge and Mr. Sherwood Washburn were interested in making an extensive collection of anatomical and taxonomic specimens for the study of intra-species structural variations. (2) The writer was interested in making a systematic field study of the naturalistic activities of the gibbon in its native habitat and a preliminary study of the orang outan. (3) Mr. Coolidge and his assistant, Mr. J. G. Griswold, were concerned in making a general collection of the birds and mammals of the region visited in Siam and Borneo. The expedition carried out its field work

in Siam, British North Borneo and Sumatra during the first nine months of 1937 and returned to the United States, having achieved its objectives to a degree beyond all expectations.

The major part of the collecting of primate specimens was done on Doi Internon and at Doi Chiengdao in northwestern Siam, not far from the Burmese border. Additional and important primate and general collecting was done in Borneo, where specimens of orang outans and proboscis monkeys were secured. However, the report of the Collecting Division is another story, and I shall deal in this article with some of the results of the Behavior Research Division, for which I was responsible.

In the plans for the expedition, I proposed to accomplish the following: (1) To make a systematic study of all observable modalities of the behavior, social relations and ecological relations of gibbons in the wild. (2) To make moving pictures and sound recordings of gibbon behavior. (3) To collect a small group of live gibbons to serve as the nucleus of a breeding colony which had been planned in connection with the School of Tropical Medicine at San Juan, Puerto Rico. (4) To conduct, in cooperation with Mr. Coolidge, a preliminary survey study of orang outans in the State of Atjeh, Sumatra, with the view of getting data which would make it possible to plan wisely and soundly a field study of this magnificent anthropoid. These objectives were achieved.

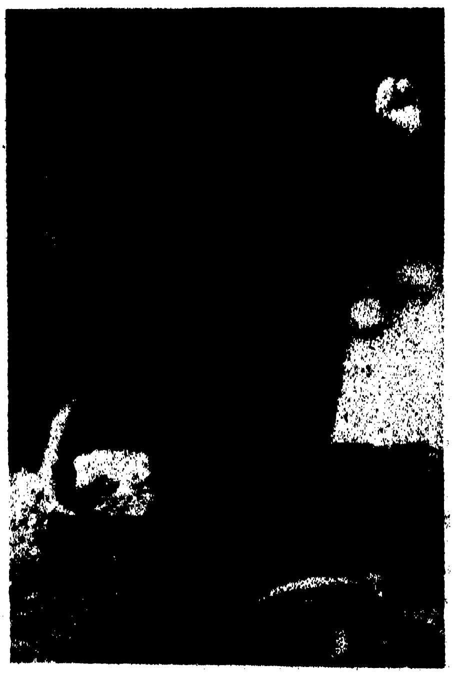
Behavior of Gibbons in the Wild

The scientific name for gibbons, *Hylobatedae*, signifies that they are forest travelers, and indeed they are! They are mainly arboreal, but may occasionally come to the ground for water or in order to cross short distances from one grove

REFLECTOR,

CENTER SECTION OF LARGE STRUCTURE SIX FEET IN DIAMETER, BEING USED TO PICK-UP GIBBON VOCALIZATIONS.

CAPTURED YOUNG MALE GIBBON OR GRAY COLOR PHASE OF *Hylobates* LAR, CHIENGDAO, SIAM.



YOUNG (H. LAR), IN TYPICAL SEATED POSITION.

of trees to another. During arboreal acrobatics, gibbons show two general types of locomotion, brachiating or swinging by the arms, and orthograde or walking on their inadequately developed hind legs. The swinging type comprises about 95 per cent. of the locomotor behavior in the jungle. The patterns of brachiation are well coordinated and effective, but the attempts at upright walking are awkward. When animals are brought into captivity, learning plays an important rôle in the adaptation of the ape to movement on flat surfaces.

The speed of locomotion is not as great as I had been led to believe from a review of the literature. The movements are fairly swift but sporadic. For a short period the apes may travel so rapidly that it is difficult to follow them on the run, as they make a kind of glide from tall trees to distant lower points. At such times they seem to touch limbs rather for guidance than support. However, these bursts of speed are of short duration and soon the animals slow down so that they may be followed easily, or indeed they may stop and rest. Nevertheless, the apes show remarkable visual-motor coordination which may reflect a very fast reaction time to visual stimuli and to judgments of distance and size.

The gibbon and the orang outan are the most arboreal of the anthropoid apes. Anthropologists postulate that the general posture and locomotor pattern as well as the other behavioral adaptations of gibbons may represent an evolutionary stage which is closely analogous to adaptations probably shown by the fossil ape *Dryopithecus*. Undoubtedly there have been deviating specializations, but the gibbon may be the nearest living approximation to the pre-human, pre-anthropoid common primate ancestor which lived in the Oligocene geological period. Thus, the study of gibbons takes on considerable theoretical significance.

Gibbons are primarily frugivorous in their food preferences. During my field work, more than forty fruit specimens were collected which made up in part the diet of gibbons in the wild. A large number of samples were also taken of stomach contents of freshly shot specimens. It was found that roughly 10 per cent. of the food in the stomach consisted of a mash composed of young leaves, flowers and buds, whereas the rest was composed of fruits and seeds. Field observations show, furthermore, that gibbons eat the eggs of birds, occasionally young nestlings and numerous insects and larvae.

Like other primates which have been studied in the wild, each group of gibbons has its specific and rather limited territorial range. The size of the territory possessed by a group relates to the size of the group, the location and concentration of preferred foods, available places for sleeping and resting or playing, pressure from adjacent groups and many other factors. Gibbons, being strongly conditioned to a limited territorial range, guard closely the area. Competition for territory, for foods and for homing areas is expressed by gibbons, as by howlers, more through aggressive and defensive vocalizations than by actual fighting. However, examinations of freshly shot specimens show cuts and torn ears which in all probability resulted from fights in which the long, keen canines were the effective weapons.

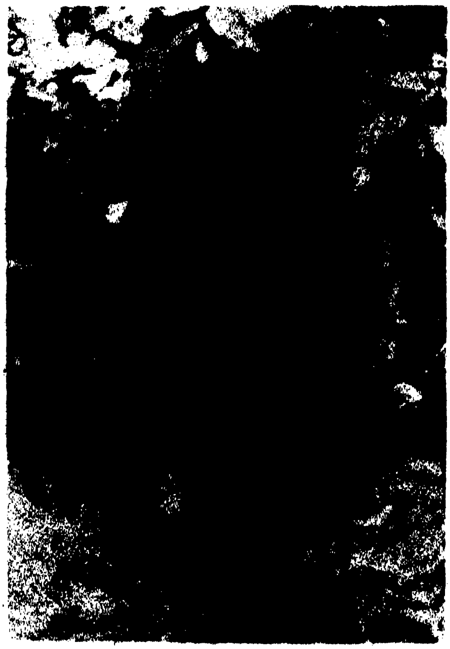
When comparison with reference to degrees of dominance and fighting are made within a large series of free-ranging primates, striking species differences are found, and furthermore, it seems indicated that arboreal primates show less tendency to pugnacity than the more terrestrial types. Another fact which is shown by field studies on competitiveness in primates is that the degree of competition is greatest within the species, a fact clearly stated by Darwin.

Field observers of wild animals have

YOUNG IMMATURE FEMALE (H. LAR) SHOWING WALKING POSTURE. ANIMAL IS SEARCHING FOR GRASSHOPPERS. CHIENGDAO, SIAM.

YOUNG MALE (H. LAR), ILLUSTRATING WALKING POSTURE.

perhaps exaggerated the competitive aspect of the animal's behavior to the neglect of accurate descriptions of socially coordinated behavior which functions importantly and advantageously for the species. In animals with highly developed bio-social behavior, there are many phases of this behavior which are highly coordinated, cooperative and mutually beneficial. I need only cite the facts that sexual activity is well coordinated and cooperative, maternal behavior involves numerous interlocking and reciprocally



ADULT FEMALE (H. LAR) IN THE WILD, SIAM. TYPICAL BRACHIATING POSTURE.

beneficial patterns of activity, while the play of the young, the establishment and maintenance of territory and group progression, all involve components of both cooperativeness and competitiveness.

A problem of central importance in primate field studies is that of ascertaining how a given sample population is organized. Especially is it important to learn what the characteristic group patterns are for the species being studied. The study of howling monkeys on Barro Colorado Island showed that in April, 1933, 489 ± 25 individuals were found in 28 groups which ranged in size from 5 to 35, with the modal group containing 18 animals. Within the group there was a larger number of adult females than adult males; in fact, there were approximately seven females to every three males. This *socionomic* or *tertiary* sex ratio is an important variant among species of free-ranging primates and one of the main axes of the group pattern. The tertiary sex ratio refers to the ratio between the number of adult males and adult females living in groups. In howlers, some of the males do not live within the groups, but live temporarily alone. By contrast, in spider monkeys, which have a somewhat comparable socionomic sex ratio, the excess males live in groups of males only.

What are the characteristic grouping patterns for gibbons? A total of 21 groups of gibbons were located, repeatedly checked and accurately described during more than three months of continuous work at Chiengdao, Siam. The groups contained a total of 93 individuals, and there were approximately an equal number of adult males and females. The groups ranged in size from two to seven with the modal group containing four animals. The characteristic gibbon group contains an adult male, an adult female and a succession of young up to a maximum of five. When a young one has been with the parent group until four or five succeeding young have been born, it has then matured sufficiently for it to separate from the parent grouping and become a part of the nucleus of a new group.

Group splitting or apoblastosis is that process of unequal division of natural societies of animals whereby the nucleus of a new group is formed from a parent group or groups. Groups split as a result of disequilibrium in the reciprocal, intragroup motives, of which the sexual motive is one of many, and because of effects

of extra-group incentives. Sometimes in gibbon groups, as was observed in Group 1, male and female siblings separate from the parent group and form a new society.

Much remains to be learned about reproductive behavior and physiology in gibbons. Few instances of copulation were observed. These were associated with elaborate patterns of secondary sexual activities. As far as could be ascertained in the field, it seems that in gibbons there is a comparatively low rate of birth and no discrete season of reproduction. The behavior of females while caring for their young constitutes one of the most interesting subjects for hundreds of hours of observational study.

Since vocalizations constitute an important part of the behavior of free-ranging gibbons, one objective of the Behavior Research Division was to make sound recordings of the calls of gibbons and attempt to learn their functions. For this purpose, especially designed sound-recording equipment of a semi-portable type was purchased and taken to Siam. Recordings were made by a Presto recorder on 12-inch acetate aluminum discs and the recorder was also equipped with a play-back attachment. A reflector made of a steel frame on papier-mâche coated with aluminum paint and six feet in diameter was used to supplement the pick-up powers of a special, directional microphone. Three hundred feet of cable made of a steel frame on papier-mâché mote from the turn table, transformer, battery set-up, and thus the possibilities of disturbing the animals were considerably reduced.

Twenty double-faced 12-inch discs were filled with recorded sounds, many of which, needless to say, were not of gibbons but of every piping, singing, denizen of the tropical forest, including everything from bees to great hornbills. The analysis of these sound records is now in progress, and detailed reports can not be given of the results. In general it seems that there are five types or series of sound patterns. Each series is distinct, is produced in a specific situation and produces in associated animals characteristic responses. Several times it was possible to stimulate the wild animals to call by playing back to them the recordings of their own calls which had just been made.

More than five thousand feet of 16 mm moving picture films were made of gibbons. The film, which is deposited in the library of Columbia University, shows wild gibbons in all aspects of locomotion, feeding, drinking, playing, and, in general, gives a good impression of the unusual behavior characteristics of this small but zoologically significant anthropoid ape.

I collected eight gibbons in Siam, brought them to Belawan, Sumatra, from which port I shipped them via the S. S. *City of Singapore* for New York. Not a single animal was lost during shipment! All but one of these apes have been sent to the School of Tropical Medicine in Puerto Rico, where they are to become the nucleus of a free-ranging breeding colony of gibbons. The colony will be located on the small island of Santiago, which lies just off the coast of Puerto Rico. The project is to be carried out under the auspices of the School of Tropical Medicine and the Department of Anatomy of the College of Physicians and Surgeons of Columbia University. In addition to the colony of gibbons, the project will involve a large breeding colony of macaques which will be used for medical research.

The Asiatic Primate Expedition has learned much about the anatomy, behavior and social relations of one of the most interesting primates below man. It is hoped that attention may have been called again to the smallest of the anthropoids, an ape which may become of the greatest importance in many branches of scientific research.

PARTICLES OF THE COSMIC RAYS

By Dr. KARL K. DARROW

PHYSICIST, BELL TELEPHONE LABORATORIES

WHEN a new member is admitted to a small and jealously restricted club supposedly already filled for all time, the event has a dramatic aspect. When a concept is formed in a nebulous way and rapidly gains precision with the passage of the years, the story is of philosophic interest. When physicists extend their knowledge into ranges of energy heretofore unsuspected, and find them inhabited by particles classifiable as electrons but in possession of powers ordinarily unknown, and also by particles which must be put in a class by themselves—when such things are available for telling, the tale has scientific value. When evidence comes in the form of pictures so striking as those which can here be shown, the science of lifeless matter has an esthetic splendor such as rarely embellishes it. All these features appear in the recent advances of the study of cosmic rays.

The small and exclusive club consists of the subatomic particles, long supposed to comprise only the negative electron and the proton and other positive atom-nuclei. Into it the positive electron had been forced in 1932, the neutron a few months earlier; a chair was being reserved for the negative proton, which as yet has not turned up to claim it; few if any expected the actual applicant. The concept now hardening into the definite form of this applicant is that of the "mesotron." This is a particle presumed to be equal in charge to the electron, but in mass a couple of hundreds of times as great. In so naming it I follow (C. D.) Anderson's recent proposal, though other titles such as "barytron" and "heavy electron" are already more or less firmly rooted in the literature. The quality which marks it out, when it appears with enormous energy among the cosmic rays, is an extreme and almost incredible power of penetration. This means that the so-called mesotrons are able to traverse decimeters, nay even meters of lead (or of dense matter generally). Like electrons, mesotrons may be of either sign of charge. As for the cosmic-ray particles still classified as electrons, *they* are marked out by their power of producing one of the most magnificent phenomena of nature, the "shower of cosmic rays" or "shower" for short. Shower-production by the supposed electrons, penetration by the supposed mesotrons, ionization along the course of either corpuscle through air: these are the three phenomena which will furnish most of the illustrations, much of the text of this article. The story of their incorporation into the structure of physical theory will furnish the remainder.

(But negative electrons and protons, not to speak of other atom-nuclei, have been identified through having their charge-to-mass ratios measured with the aid of electric and magnetic deflecting fields in elementary classical ways. Why then do I not cut this introduction short by giving the results of such a measurement upon the mesotron? The reason is that no such measurement has yet been made. Probably one will be made ere long. Should it give something near to the result expected, the delay will not have been regrettable; for the end of the delay will mark the beginning of the time, when the story to be related in these pages will be regarded as being "of historical interest" only—which is to say, that it will then be liable to be forgotten.)

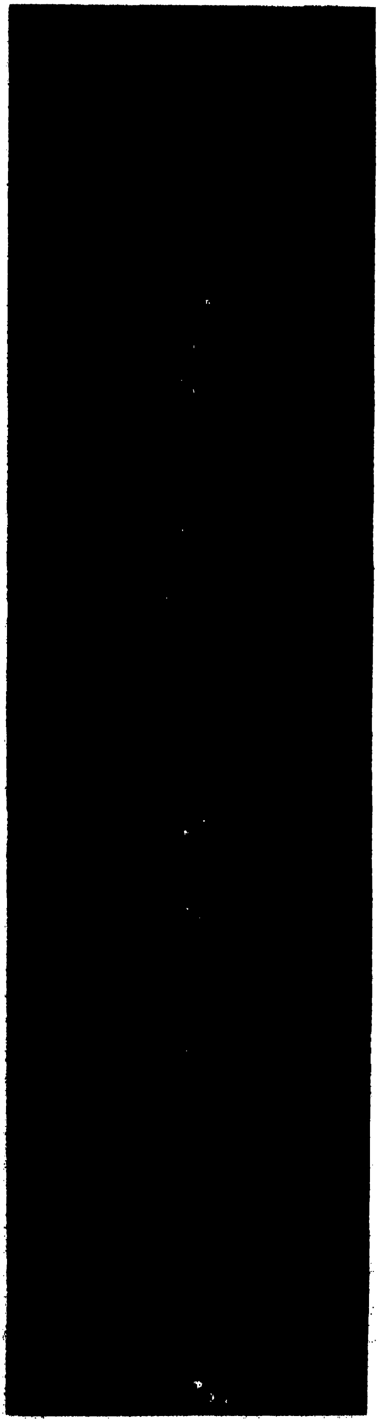


FIG. 1. TRACK OF A COSMIC-RAY PARTICLE (PROBABLY AN ELECTRON) IN THE EXPANSION-CHAMBER, TIME HAVING BEEN ALLOWED FOR THE IONS TO DRIFT APART BEFORE THE EXPANSION. (CORSON AND BRODE, UNIVERSITY OF CALIFORNIA.)

So that the reader may see at once the three phenomena which are to bulk so largely in this story, I draw his attention at once to some of the pictures which decorate this article.[1] Nearly all of them were made (of course) with the aid of the cloud-chamber or expansion-chamber of C. T. R. Wilson, that device so precious in physics and precious in so many ways.[2]

At the beginning I place, as Fig. 1, a picture of the track of a cosmic-ray particle believed to be an electron. Any one who has ever studied the pictures of cloud-chamber tracks will at once be impressed by seeing how distinctly the droplets stand apart. This separation was achieved by letting half a second elapse from the instant when the electron shot through, to the instant when by expansion the gas of the chamber grew suddenly cool and the water-vapor suspended in the gas condensed itself as dewdrops on the ions. These ions, formed by the passage of the electron, had been diffusing through the gas during the half-second intervening, and the diffusion-process had served in the main to carry them apart (though there must also have been cases of ions approaching and possibly even combining with each other). The counting of these droplets is germane to the question as to whether the traversing particle was or was not an electron. This question, however, we leave till later, and turn to photographs in which the droplets of the tracks lie close together and are uncountable, because the expan-

[1] They decorate it with particular clarity, thanks to the kindness of Messrs. Anderson, Auger, Brode, Corson, Fowler, Fussell, Neddermeyer, Stevenson and Street in supplying me with prints of their splendid photographs.

[2] The expansion-chamber contains moist air (or some other gas saturated with water-vapor) and is bounded by several fixed transparent walls and one movable wall. When the movable wall is suddenly displaced outwards by a previously decided amount, the air expands and is sharply cooled by the expansion, and the water-vapor precipitates itself in droplets upon whatever ions may be present in the chamber.

sion took place before there had been time for much diffusion. Tracks so formed have the advantage of sharpness over what they lose in detail.

Fig. 2 presents the track of a particle which traversed a plate of lead as it shot across the chamber. In passing through the lead, it underwent no sensible deflection; no other particle sprang from the lead; and there is nothing in the aspect of the track which differs on the two sides of the metal. It would be more impressive yet to present a similar picture for a particle traversing ten or fifty centimeters of lead, but here the practical limitations on the size of a Wilson chamber defeat the physicist, or at any rate no one has overcome them yet. Ehrenfest has lately circumvented them by the laborious scheme of setting up *two* Wilson chambers, one above the other, with as much as 9 cm of lead or gold between them. However, the passage of single charged particles through thicknesses as great or even much greater is amply attested by the scheme of apparatus sketched in Fig. 3, even without the cloud-chamber there indicated by "Ch."

In this sketch of Fig. 3, the objects C_1 and C_2 and C_3 are Geiger-Müller counters: that is to say, gas-filled discharge-tubes of a very special design, the two electrodes of each being an axial wire and a coaxial cylinder, and the electrode-size, voltage and gas-content being very carefully adjusted. These long large cylinders, usually called simply "counters" without the prefixed names, are familiar sights in almost every laboratory where cosmic rays are studied. If a charged flying corpuscle penetrates such a tube, a momentary discharge takes place in the gas. If such discharges spring up simultaneously in all the three tubes of such a system as Fig. 3 exhibits, the event is recorded by a mechanism. ("Simultaneously" is of course a word which requires detailed exegesis; it meant at first that in all tubes discharges began within 0.01 second of each other, but this interval has been pushed down to .0001 second and lower.)

These events, the "threefold coinci-

FIG. 2. TRACK OF A PARTICLE, PRESUMABLY A MESOTRON, TRAVERSING A METAL PLATE WITHOUT SENSIBLE DEFLECTION. THE WHITE BANDS IN SUCH PICTURES ARE DUE TO LIGHT REFLECTED FROM THE SURFACE OF THE PLATE. (AUGER; UNIVERSITE DE PARIS.)

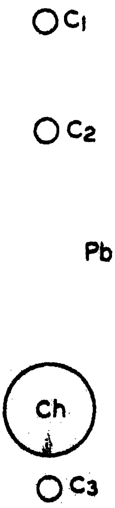


FIG. 3. SCHEME OF APPARATUS FOR OBSERVING VERY PENETRATIVE PARTICLES WITH COUNTERS AND CLOUD-CHAMBER.

dences," do actually occur. Of course, since in each of the tubes a discharge occurs now and then by itself, some of the coincidences must be the result of chance; but the probable number of these meaningless ones can easily be estimated from the frequency and the duration of the individual discharges, and in the best experiments they are a small minority. For the great majority, the simplest of explanations is to attribute each of them to a single vertically-flying particle cutting through all the counters in succession. Yet there are other thinkable causes, and confirmation of this simplest idea is needed. It was supplied when the cloud-chamber, "Ch" in the figure, was inserted. The chamber was compelled by mechanism to expand, always when and only when a threefold coincidence happened; and at the great majority of its expansions it showed a vertical track. Fig. 3 exhibits the arrangement of Street, Woodward and Stevenson at Harvard, who found the track of the traversing particle at 202 expansions out of 219. Auger and Ehrenfest at Paris had already set up *four* counters and a cloud-chamber and a block of lead in a vertical line, and found the track of the single traversing particle at fifty-five expansions out of sixty-nine. Another test is made by displacing one of the counters out of line with the others, whereupon it is found that the coincidences fall off in number sharply. And now to come to the point which most concerns us: there were 45 cm of lead between the counters in the experiment of Fig. 3, and 50 cm in the experiment by Auger and Ehrenfest, and no fewer than 101 cm in an early experiment of Rossi's with counters though without the chamber! Such is the power of penetration of some of the charged corpuscles of the cosmic rays.

The reader has now been introduced to charged particles which bore through quantities of lead, apparently without doing or suffering anything. Next he is to be introduced to particles which begin

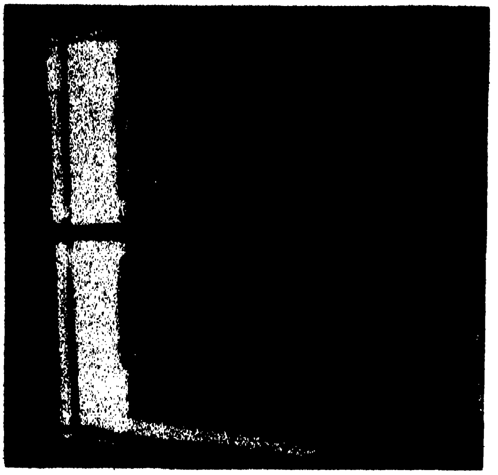


FIG. 4. THREE SHOWERS, TWO EVOKED BY CHARGED PARTICLES AND ONE PRESUMABLY BY A PHOTON. (STREET AND STEVENSON, HARVARD UNIVERSITY.)

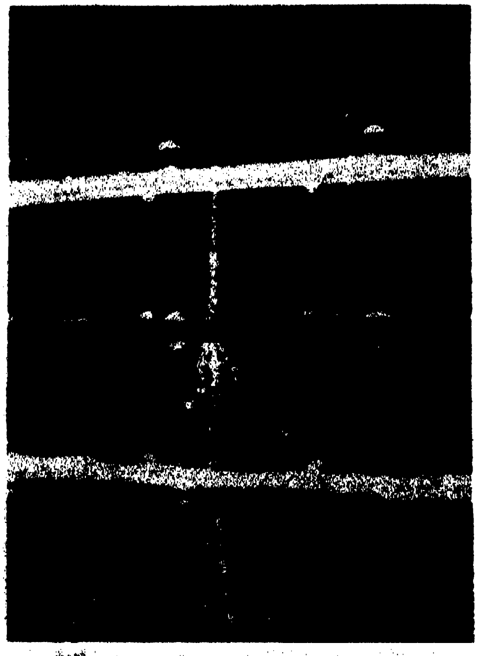


FIG. 5. SHOWER BEGUN BY A CHARGED PARTICLE IMPINGING ON A 6.3-MM LEAD PLATE, AND MULTIPLIED AS IT PASSES THROUGH A SECOND SUCH PLATE; IN THE THIRD PLATE, 0.7 MM THICK, ONLY DEFLECTIONS OCCUR. (FUSSELL, HARVARD UNIVERSITY.)

FIG. 6. SHOWER COMPRISING PHOTONS ATTESTED BY THE (CURLED) TRACKS OF SLOW ELECTRONS RELEASED IN THE GAS. (ANDERSON AND NEDDERMEYER, CALIFORNIA INSTITUTE OF TECHNOLOGY.)

FIG. 7. ANOTHER EXAMPLE OF A SHOWER UNDERGOING MULTIPLICATION AS IT PASSES THROUGH METAL PLATES. (FUSSELL.)

to do something startling, when they have scarcely more than entered into a thin metal plate. This is vividly shown to him in Fig. 4, in which—after he can detach his eyes from the pretty sight beneath the transverse leaden plate—he will see that two of the "showers" beneath spring from the places where the metal was entered by two charged particles coming from above. These are accordingly called "shower-producing particles."

Figs. 5 and 6 and 7 show examples of showers even more gorgeous—regular cloudbursts, to continue with the metaphor (and indeed the term "burst" is often used as a synonym for "very large shower"). Of these, the special value of Fig. 6 is that the tracks that start in the gas itself bear witness to corpuscles of light—photons—included in the shower; for these are the tracks of electrons ejected by photons from atoms of the gas. (The agent which bends them into curlicues is, of course, a magnetic field applied to the whole of the Wilson chamber.) Showers, then, comprise photons as well as charged particles. The special value of Figs. 5 and 7 is that they show the progressive aggrandizement of showers as these pass onward through dense matter. This is called "the multiplication of showers." *Shower particles are themselves capable of being shower-producing particles.* One could not tell from these figures whether the multiplication is due to the charged particles or the photons, to either singly or to both. Here again the reader may consult Fig. 4, in order to notice that one of the three showers there depicted sprang from a place in the plate to which no charged particle came. This suggests that a photon may cause a shower, and that the multiplication of a shower already begun is due to the action of its charged particles and of its photons both.

Two classes of charged particles begin to take shape: the penetrating ones on the one hand, the shower particles and the shower-producing particles classified together on the other. To bring out another aspect of the distinction, I now turn to the data underlying Fig. 8.

These data are derived from cloud-chamber photographs such as Fig. 9 exemplifies. If the track of a charged particle is sensibly curved in such a magnetic field as it is possible to apply to a Wilson chamber, it may be possible to infer the momentum and the energy of the particle.[8] I digress to give the formulae, so as to make it clear just what can be de-

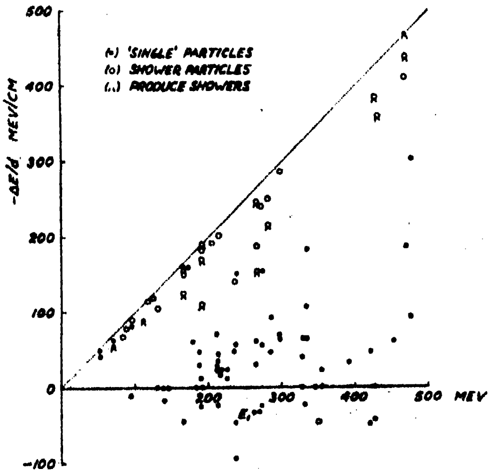


FIG. 8. ENERGY-LOSSES PER UNIT LENGTH OF PATH (IN MEV/CM) SUFFERED BY 94 COSMIC-RAY PARTICLES IN TRAVELING THROUGH PLATINUM. (ANDERSON AND NEDDERMEYER.)

duced from what amount of knowledge. The elementary procedure consists in pointing out that the charged body describes a circle in the plane perpendicular to the magnetic field, and that consequently the force exerted on it by the field is to be equated to the product of its mass by its centrifugal acceleration. Putting ne for the charge (in electrostatic units) of the corpuscle, m for its mass, v for its speed and p for the magnitude of its mo-

[8] Curvatures of tracks being so very important in this field of research, it is necessary to examine with the greatest of care into all of the causes (apart from magnetic field) which may produce or affect them. Notable among these

mentum in the plane normal to the field, ρ for the radius of the circle and H for the field-strength, and writing down the two members of the equation, one finds:

$$Hnev/c = mv^2/\rho, \qquad (1)$$

$$p = (ne/c)H\rho. \qquad (2)$$

These equations remain valid when (as usually is the case with cosmic-ray electrons) the speed is so great that relativistic mechanics must be used instead of ordinary. At such high speeds equation (2) retains its aspect. Equation (1) may also be left unaltered, but one must be sure to remember that m is a certain function of v:

$$m = m_0 \sqrt{/1 - v^2/c^2}, \qquad (3)$$

m_0 being known as the "rest-mass" of the body.

Equation (2) does not involve the mass at all. In the usual loose phrasing, $H\rho$ *gives the momentum of the particle provided that its charge is known.* The like can not be said for the energy, which is given by $H\rho$ only if both the charge and the rest-mass are known. For particles of the cosmic rays it is best to disregard the ordinary expression for kinetic energy ($\frac{1}{2}mv^2$) and adopt for good the relativistic expression mc^2, to wit, $m_0c^2/\sqrt{1 - v^2/c^2}$. Of this the portion m_0c^2 is not kinetic energy: it is the "rest-energy" associated with the "rest-mass" m_0, inseparable from the particle so long as this exists; it amounts to about half-a-million electron-volts or 0.5 Mev for the

are currents in the gas, which are especially obnoxious if there is a metal plate in the chamber. Indeed it seems strange that the currents should not be more hampering than they are, considering the expansions which occur. Sometimes people observe that in the absence of magnetic field, there is a slight curvature of the tracks; then in the presence of magnetic field, they deduct this amount from the curvatures observed. The papers of Anderson and Blackett abound in information on these delicate questions.

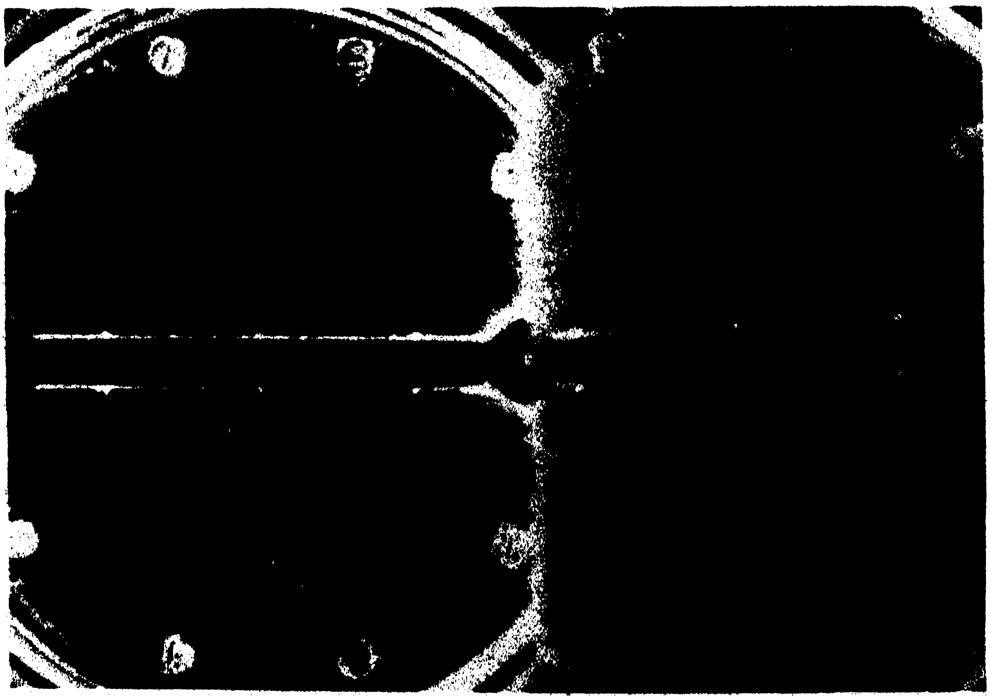


FIG. 9. TRACK EXHIBITING MEASURABLE AND UNEQUAL CURVATURES ON THE TWO SIDES OF A METAL PLATE, THUS INDICATING CHANGES OF ENERGY AND MOMENTUM SUFFERED IN THE TRAVERSAL. (ANDERSON.)

electron, to about 1,000 Mev for the proton. The remainder may be called kinetic energy. For nearly all the electrons and most of the other cosmic-ray particles, this remainder is by far the greater part. The dependence of the kinetic energy upon $H\rho$ is exhibited, for electrons and for protons, by Fig. 13. One sees that for different masses a given $H\rho$-value leads to different energy-values, but also that the error due to an incorrect estimate of rest-mass becomes proportionately smaller as the $H\rho$-value increases. Yet the possibility of the error *is* always there, if the mass of the particle is not certainly known; and it affects many published "energy-values" based on the presumption—often admitted in the context to be more than doubtful—that the particles to which they refer are electrons. The danger might be mitigated by describing these as "quasi-energy-values" expressed in "quasi-Mev."—For actual electrons with momenta as great as those figuring in the cosmic rays, the energy-value in electron-volts is practically equal to 300 times the $H\rho$-value expressed in gauss-centimeters.

Many a cosmic-ray particle suffers no deflection that can be detected in its entire course across a Wilson chamber (diameter, 15 cm or even more) in a magnetic field as strong as can be applied over so great a volume (field-strength, 20,000 gauss or thereabouts). One might well be tempted to think such a particle chargeless, for if this were the case, the field would have no grasp at all upon it; but if it were chargeless it could not ionize the molecules of the gas and therefore could not form the chain of ions on which the droplets are founded. In some of the finest of the experiments (those in Pasadena and those in Paris) a detectable curvature of the track would be shown if this were made by an electron of energy so enormous as $2 \cdot 10^{10}$ electron-volts (20,000 Mev!). The uncurved tracks accordingly speak of electrons of energies greater than 20,000 Mev, if these particles are electrons; and the inference is not much less drastic, if they are more massive than an electron.

We, however, are more interested, for the present, in the tracks which are sensibly curved; and most of all, in the tracks which are intersected by a metal plate and which show a curvature on one side of the plate and a larger curvature on the other (Fig. 9). From the two ρ-values one can deduce the momentum-loss Δp and the energy-loss ΔE suffered by the particle in passing through the plate. (Yet I emphasize again that Δp is computable only if the charge is correctly guessed, and ΔE only if the rest-mass is correctly guessed in addition to the charge.) With this ambition Anderson inserted such plates for the first time into a Wilson chamber, in 1931. The idea had a wonderful and unforeseen result, some years ago recounted in these pages. Notice that above I spoke of the momentum-*loss* and the energy-*loss* suffered by a particle in going through a plate. In so doing I was making the assumption that it is a loss and not a gain which happens. If this highly plausible assumption is correct, then the sense in which the particle is traveling its path is knowable; it is from the side of the plate on which the curvature is less, to the side on which the curvature is greater. If the sense of the motion is knowable, so also the sign of the charge of the particle is knowable, being positive or negative according as the track is bent with its concavity toward the left or toward the right of an observer looking into the chamber from the north-seeking pole of his magnet. Without the plate, neither sense nor sign would be knowable except in the rarest of cases.[4] Anderson in August, 1932,

[4] One might be misled by the adjective "cosmic" into believing that all cosmic-ray particles come from above, their sense of motion making an angle of less than 90° with the downward-pointing vertical. Many, however, including Anderson's first positive electron, have been

found on one of his photographs the track of a particle which by this criterion was positive, and which by the density of droplets along its track (we take up this topic later) he identified as an electron. He thus became the discoverer of the positive electron.

Concentrating on the measuring of ΔE after the excitement of the positive electron had subsided, Anderson presently found that its values are very fluctuating. Thus in 1934 he published the details of nine traversals, made by particles assumed to be electrons, through thicknesses of lead from 7 to 15 mm. (Even with a single metal plate the effective thickness varies, since corpuscles traverse the plate with varying degrees of obliqueness.) These were by no means identical in initial energy, this ranging from 38 to 240 Mev; nevertheless, one might have expected the energy-loss per unit length of path in lead to be about the same for all, and yet the nine values thereof were scattered all the way from 18 to 120 Mev/cm! Such fluctuations suggest that the energy is lost in great amounts at a few events, and not in driblets at many. They did not deter Anderson and Neddermeyer from making such measurements on hundreds of later particles, classifying the particles into groups according to their energy-values, and averaging the energy-losses within each group. What then was found has a bearing upon the problem; but we pass over it for the time being, and consider in Fig. 8 the record of ninety-four particles which, during a later experiment, passed through a plate of platinum one centimeter thick.[5]

Plotted horizontally are the energy-values of the particles while above the plate, vertically the energy-changes divided by the lengths of path in the platinum. The axis of abscissæ is the locus of energy-losses imperceptibly small; the line slanting at 45° is the locus of energy-losses which are total, the particles shown on this line having been stopped by the plate. The fact that some of the representative points lie below the horizontal axis means only that for every particle the observers subtracted its energy below the plate from its energy above, irrespective of its direction of motion. Suppose that these subjacent points correspond to upward-going corpuscles, and transfer them across the horizontal axis. Then, the sprinkling of points extends all the way from axis to slanting line; and this is the sign of fluctuations such as Anderson from the start had observed. Notice, however, that the representative points are of four aspects: solid dots and hollow circles, with or without downward-pointing barbs. The dots refer to tracks which were seen in the chamber singly; the circles to particles which "entered the chamber accompanied by other particles." The lonely particles are prevailingly able to pass through matter without suffering energy-losses nearly so great as those which the others incur! Thus by itself and without any theory, Fig. 8 establishes a distinction between the singly-appearing corpuscles on the one hand and those which appear in company on the other. Moreover, the barbs are often attached to the hollow circles, bearing out the inference from Figs. 5 and 7 that shower particles are likely to be shower-producing particles; but rarely are they attached to solid dots, never to those which lie far off from the slanting line.

(This seems the best place for mention of the similar work now being done in England by Blackett and (J. G.) Wilson, in France by Ehrenfest.[6] The Englishmen have set plates of gold, lead, copper and aluminum, of various thicknesses from 3.3 mm to 2 cm, into the middle of an expansion-chamber in Anderson's fashion; Ehrenfest, using a pair of cloud-

found by this criterion to be moving upward (*i.e.*, at more than 90° to the downward-pointing vertical). The showers of Figs. 6 and 7 show that this is not a forced interpretation.

[5] I am indebted to Dr. Anderson for a plate exhibiting data thus far unpublished.

[6] I regret to mention the sudden untimely death of this brilliant and amiable youth.

chambers one over the other, was able to put between them a block of gold no less than 9 cm thick! Their way of reducing their data for plotting is not the same as that employed at Pasadena, and their diagrams therefore look very different[7] from Fig. 8. Their energy-range runs much further upward, as far as 5,000 Mev, and the great majority of the particles which they plot lie beyond the limit of Fig. 8. Many of Ehrenfest's particles got through the great thickness of gold without losing anywhere nearly the whole of their energy, and are therefore to be classed as much more penetrating than electrons should be. So did nearly all the particles of energy greater than 250 Mev observed in England, but there were a few of these which lost most of their energy in 0.33 cm of lead, and of these few about half seemed to belong to showers. At energy-values below 200 Mev Blackett finds almost no penetrating particles, a singular contrast with the Pasadena observations; he suspects that the penetrating particles become ordinary electrons when they are slowed down into this energy-range. I mention also the measurements made on some twenty penetrating corpuscles by Leprince-Ringuet and Crussard, leading to the exceptional conclusion that positives suffer smaller energy-losses than negatives.)

But granting that there are two sorts of particle with a right to different names: has either a right to the name "electron"? To settle this question, and for several other reasons, it is time to call upon theory.

It is now some thirty years since there entered into physics a German word, *Bremsstrahlung,* which can be translated literally into English as "braking radiation," and would no doubt be so translated if "braking" did not sound like another English word of entirely different meaning. This is chiefly observed emerging from x-ray tubes, being emitted from their metallic targets when these are struck by the stream of bombarding electrons. It consists of photons or corpuscles of light, each containing at least a part of the kinetic energy of one of the incident electrons. The distribution-in-energy of the photon makes it clear that the electrons frequently lose large fractions of their initial energy *en bloc,* throwing it off in individual parcels which are these photons (indeed it sometimes happens that the entire kinetic energy of an incident electron is shed in the form of a single corpuscle of light). This radiation forms the so-called "continuous x-ray spectrum" or "x-ray continuum" emerging from targets of x-ray tubes. With the spectrum-lines which are sometimes seen superposed on this continuum we have nothing here to do.

By the classical theory of thirty years ago this continuous spectrum is attributed to the slowing-down of the electrons as they penetrate into the metal, whence the name *Bremsstrahlung.* By the quantal theory of to-day it is still ascribed to the slowing-down, which must now be conceived as taking place in instantaneous jerks, occurring probably in the close vicinity of atom nuclei. At each of the jerks, the electron-speed is suddenly reduced and the kinetic energy goes forth in the form of light. The later theory in its quantitative form gives a competent account of the continuous x-ray spectrum as it springs from the tubes of the laboratory, with their bombarding electron-

[7] For the benefit of those who may consult the original papers, I give the difference. Let E_1 and E_2 stand for the (quasi) energy-values of a particle before and after passing through a thickness d of metal; ΔE for $(E_1 - E_2)$; x for $\frac{1}{2}(E_1 + E_2)$. What is plotted by Anderson and Neddermeyer (Fig. 8) is $\Delta E/d$ as ordinate and E_1 as abscissa. Blackett (in all his papers but the earliest), Wilson and Ehrenfest begin by subtracting from ΔE a quantity sd which is supposed to be the amount of energy spent by the particle in detaching electrons from atoms while traversing the metal (Blackett assigns the value 15 Mev/cm to s in lead, Ehrenfest takes 28 for gold); they then plot $(\Delta E - sd)/xd$ as ordinate and x as abscissa. Their ordinate (denoted by them as R) is then more nearly ready for comparison with theory.

streams energized by voltages of a few tens or hundreds of thousands. For a long time nobody seemingly troubled to extend it to voltages of the order of thousands of millions; a futile extension indeed this would have been, so far as x-ray tubes are concerned. When finally the extension was made by people interested in the cosmic rays, it turned out that according to the quantal theory the liability of electrons to these "radiative energy-losses" goes up so greatly with increasing speed that electrons of even the cosmic-ray energies should not be able to bore their way through as much as five centimeters of lead!

After the meaning of this inference sank in, there ensued a period lasting for months (in 1935 and 1936) in which several eminent theorists were willing to concede that nature must have set a limit to the scope of quantal theory. It was beginning to be believed that somewhere between the energy-range attainable in the laboratory and the energy-range manifest in the cosmic rays, there is a critical energy-value beyond which the electron escapes from the sway of the quantal laws, and is exempted from losing its energy by the process of *Bremsstrahlung*. This belief was an artifice for permitting the penetrative particles of the cosmic rays to be called by the name of electron. It might have remained a credible artifice, if the penetrative particles had been the only ones—if, that is to say, there had never been any evidence for the existence of particles among the cosmic rays having the properties required of electrons by the quantal theory. Such a situation may have seemed to exist at the time when the belief was dominant. It exists no longer, as the description of Fig. 8 has just suggested; but before considering further the data, I must introduce something more of what the theory has to say.

Since 1934 it has been known that a photon of energy greater than about one million electron-volts is capable, when in the vicinity of an atom-nucleus, of converting itself into a pair of electrons of opposite sign. About one million electron-volts—1.02 Mev, to be somewhat more precise—becomes "rest-energy" of the twin electrons, being incorporated with their rest-masses; the remainder ($h\nu - 1.02$, if by $h\nu$ we denote the photon-energy in Mev) becomes kinetic energy of the electrons. The process may be produced at command and exhibited to the eye, by projecting the photons known as gamma-rays against metal targets contained in expansion-chambers. The gamma-rays originally used for this purpose proceeded from natural radioactive substances; mostly they were those emitted by a certain substance (thorium C'') with a photon-energy of 2.62 Mev. Nowadays gamma-rays of energy several times as great can be produced by effecting certain transmutations, in the course of which (or afterward) they emerge from the new-born nuclei. Fig. 10 shows an admirable example of an electron-pair formed out of such a photon. Moreover, the converse process is well known: positive electrons falling against a plate of dense matter bring about the emission of photons of energy 0.51 Mev, and these are just what are to be expected if the positive electrons (after being slowed down) unite with some of the innumerable negative electrons already in the plate and produce, at every such union, a pair of equal photons.[8] Much too abundant to be here described is the evidence for the ability of electron-pairs to pass into light and light to pass into electron-pairs, making it permissible to imagine a

[8] Evidently this is not quite the converse of the process previously described, which if reversed would consist in the merger of a positive and a negative electron with the formation of a single photon bearing away all their energy. Some evidence exists for the occurrence of this process. There is no sign of the fourth conceivable process (the meeting and merger of two photons to form two electrons) which must obviously be very rare in practice owing to the feeble concentration of photons in actual beams of gamma-rays. Nevertheless, this last is the process first predicted by the theorist Dirac.

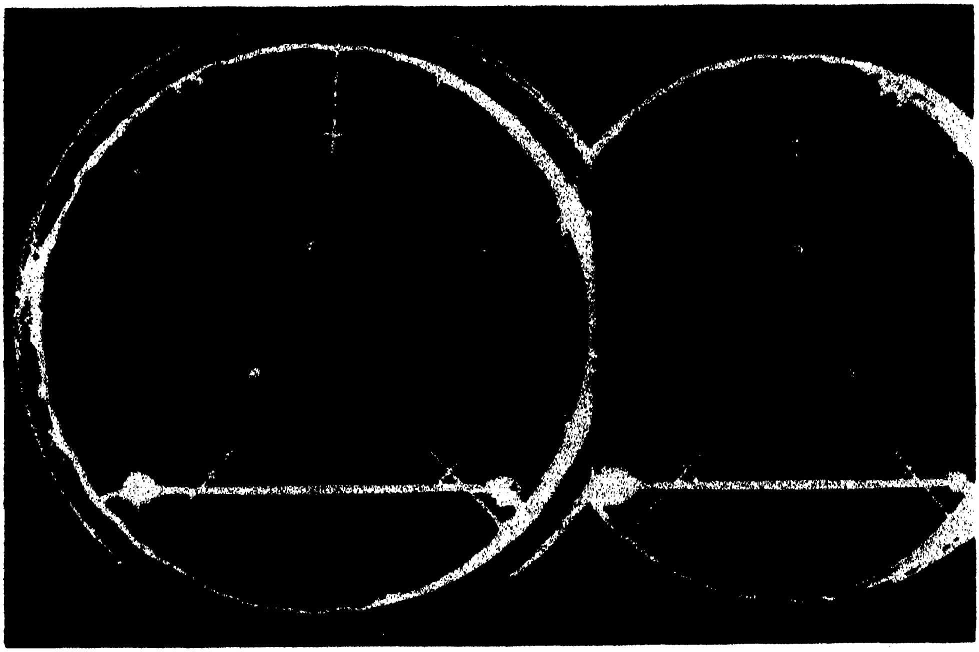


FIG. 10. AN ELECTRON-PAIR BORN FROM A PHOTON. (W. A. FOWLER, CALIFORNIA INSTITUTE OF TECHNOLOGY.)

continual alternation of energy between these two so sharply contrasted forms.

Formation of the photons of *Bremsstrahlung* by electrons of enormous energy and formation of electron-pairs out of such photons: these reciprocal processes engaged the attention of several theorists (Bethe, Heitler, Sauter, Weiszaecker, Oppenheimer) in the years 1933 and 1934. The problem was to evaluate by quantal theory the chance that electron or photon would spend its energy in producing photon of electron-pair, while traversing given thickness of given element. Approximations had to be made in the calculation, as nearly always in quantal problems; but they are supposed not to affect the rightness of the main result. To quote Oppenheimer's description of this result: "a beam of high-energy electrons should have a good part of its energy converted into photons in a centimeter of lead; in an equal distance these photons will be largely reconverted into pairs."

Such was the result from which, in 1935, it was inferred that quantal theory must be wrong because it was predicting something which could not be found in nature; and from which, in 1936 and thereafter, it was concluded that quantal theory not only was correct but had made a splendid triumph, in explaining the phenomena of showers! It is not altogether clear why the later conclusion was not drawn at the start; perhaps the reason is that as lately as the summer of 1936 fine photographs of showers were still rather rare, while such pictures as Figs. 5 and 7 with their examples of self-augmenting showers had not as yet been made. On the other hand, it would be premature to say and misleading to imply that the process which the theory describes is in exact and quantitative accord with the observations on showers. There are at any rate good grounds for hoping that as the mathematics of the theory is more fully worked out and the art of the experiments refined, the agreement will grow better and better. The most that seems safe to say is, that now we have a

general scheme for the interpretation of showers of a certain type, and a very hopeful prospect that this general scheme will be converted into a detailed and quantitative explanation as the mathematics of the theory on the one hand, the aptness and precision of the observations on the other hand are gradually improved.

By inserting the words "of a certain type" in the foregoing sentence, I leave open the possibility that showers may be classified into more than one type, and all these but one be ascribed to other processes. This is no mere possibility but already almost a certainty. Certain showers which include "heavy tracks" due to protons or still more massive particles are ascribed to nuclear explosions provoked by cosmic rays. If a shower fails to undergo the "multiplication" illustrated in Figs. 5 and 7, it is taken as belonging to this other type. Exception made for such cases, it is strongly plausible to say that shower particles and shower-producing particles are electrons; that accordingly high-energy electrons exist among the cosmic rays, behaving as the quantal theory says that they should; and that consequently the other particles, setting themselves apart from electrons by their penetrative power and their failure to make showers, are of another sort.

Ability to penetrate matter, inability[9] to make showers: these are the complementary aspects of the property which distinguishes this other type of particle, the mesotron. If one wishes to contrive a particle having this property and differing otherwise as little as possible from the electron, how must it be done? The electron has the qualities of charge and mass; also those of spin and magnetic moment, but these are considered (perhaps wrongly) to be little or not at all concerned with shower-production. If we imagine the mass to be increased while the charge remains the same, the liability to *Bremsstrahlung* will diminish; for *Bremsstrahlung* occurs when sudden sharp deflections or decelerations occur, and these are less sharp and sudden the more massive the particle is. Now *Bremsstrahlung* is the prelude to the entire manifold process of the forming of a shower, and hence a mere increase in the mass of the hypothetical particle leads in the desired direction. The theory indicates that a particle with the electronic charge and a few dozen times the electronic mass will be penetrating enough. We do not need, however, to be contented with such vague intimations, for there is yet another phenomenon in respect of which the mesotron differs from the electron, and from this the mass can be deduced more sharply.

So far, we have been considering the passages of particles through solids. There, the paths are concealed, the adventures of the particles can only be inferred—from the difference between energy before and energy after traversal, or from the photons and the secondary electrons which are driven out of the solid. Now we are to consider the passages of charged particles through the gas of the Wilson chamber, which, unlike the scriptural way of the eagle through the air, are preserved for our inspection by the droplets. Fig. 1 has shown to us a track in which the number of droplets in unit length of path can rather readily be counted. What does this number signify? And is it truly an indication of the mass of the traveling particle, as I hinted on an early page?

The latter question might perhaps be sufficiently answered without reference to the former; but for completeness, and for the sake of its own interest, the former ought to be treated more fully than it was in that brief earlier mention. In the voyage recorded in Fig. 1, nothing so drastic happened to the traversing particle as would have been the losing of a large part of its energy in the form of a photon of *Bremsstrahlung*. It lost its

[9] It is better to say "relative inability" since occasional showers are attributed to mesotrons, which perhaps operate by making a violent impact on an electron and so giving it the energy needful for starting the process.

energy in driblets, spent in detaching electrons from molecules and giving them a small extra bonus of kinetic energy with which to go wandering around in the gas. They had not speed enough to wander far, even in the half-a-second afforded them before the condensation. Probably they had already adhered to molecules before the condensing water immobilized them. One speaks of the droplets as being condensed partly on negative, partly on positive ions; the last-named are the molecules from which the electrons were reft. (If, during the half-a-second, an electric field of suitable strength is applied, the ions of the two signs drift in opposite ways, and when the water-vapor comes down there are seen two parallel trails of droplets with an empty space between.)

The simplest idea is that the traversing particle tears off one electron from each of many molecules through or near which it passes, and that half of the droplets are formed on these electrons and the other half upon the molecules bereft. This is too simple to be true. It is likely that sometimes the particle removes two electrons or more from a single molecule, so that there well may be more negative ions than positive. Much more serious is the certain fact that often when an electron is thus released by the direct action of the traversing particle, it shoots away with speed and energy enough to enable it to release one or several more from neighboring molecules. Now and then one comes on a cloud-chamber photograph in which there appears a track with branches (Fig. 11); each of these is the trail of an electron which has received a truly abnormal and extraordinary amount of energy. Much commoner, in fact universal, is the "beaded" appearance of such trails as appear in most of the pictures of this article: it is presumed that each of the beads is an unresolved cluster of droplets formed on a cluster of ions, all but one pair of them made in the indicated way. Occasionally one sees a picture in which the interval allowed for diffusion has been so happily chosen that the droplets in the clusters are far enough apart for counting, and yet consecutive clusters do not overlap. In making Fig. 1 the interval allowed was a little too long, and yet perhaps it is possible to think that the ions are denser in some parts of the trail than in others, as though they had been formed in clusters which have broadened almost but not quite to the point of losing their identity.

It is therefore necessary to distinguish, in mind if not in fact, between the "primary ionization" consisting of the electrons and the molecules torn apart from each other by the direct immediate action of the traversing particle,[10] and the "entire ionization" (sometimes called "probable ionization") consisting of these together with all the ions formed by the directly ejected electrons. Under ideal conditions it is presumed that the measure of the former would be the total number of droplet-clusters,[11] the mea-

[10] Unluckily called "secondary ionization" by some of the German theorists.

[11] Best to observe the droplet clusters as individual entities, one would wish the expansion to occur before the ions have any time at all to diffuse. To attain this, Williams and Pickup caused the chamber to expand at moments taken at random, and trusted to luck for the appearance of cosmic-ray tracks formed at just the right instants. Luck served them with no fewer than four tracks betokening particles of a distinctive

FIG. 11. TRACK OF A CHARGED PARTICLE BRISTLING WITH SHORT BRANCHING TRACKS, MADE BY ELECTRONS EJECTED FROM ATOMS WITH ENERGY SUFFICIENT TO IONIZE. (AUGER.)

sure of the latter would be the total number of droplets, in unit length of path. Not many physicists have tried to evaluate both of these numbers. Of those who have, the data have been scanty, but the consensus of opinion is that the latter is about or not quite twice as great as the former. It is, however, likely that the value of the ratio of the two is not important when one wants only to distinguish between electron and mesotron, as we shall presently see.

The problem of the primary ionization is one of the major tasks of theoretical physics. Classical and quantal theorists alike have spent great labor on the question: given a charged particle of specified charge and mass and speed traversing air (or any other gas), how many electrons will it set free from the molecules in unit length of path? At this point I will give only one of the results—or rather, something which is not a result at all, but a part of the assumptions. It is assumed that as the traversing charged particle flies along through or close to a molecule, it operates upon the electrons thereof by virtue of the ordinary electric forces between its charge and the charges of the electrons. It follows, then, that *whatever expression finally may be derived for the primary ionization must depend only upon the charge and the speed of the traversing particle, and not upon its mass.* (Mass and momentum of the particle must indeed be great enough to hold it on a sensibly straight course as it plows onward through the gas, despite its losses of energy as it detaches electrons; but this condition is always realized, with the corpuscles of the cosmic rays.)

I seem to have said that the primary ionization gives no power of distinguishing between an electron on the one hand, a particle of equal charge and different mass on the other. However, it *does* confer on us this power, for the reason that the curvature of a particle-track in a known magnetic field is a measure not of particle-speed but of particle-momentum

FIG. 12. TRACK OF A MESOTRON SLOWED DOWN BY AN OBSTACLE IN A WILSON CHAMBER AND FINALLY BROUGHT TO A STOP IN THE GAS OF THE CHAMBER ITSELF. (NEDDERMEYER AND ANDERSON.)

(equation 2). If by luck an experimenter should happen upon two tracks having the same curvature but made by particles having masses[12] standing to one another in the ratio (say) 100:1, the speeds would stand to one another in the ratio 1:100, and this might well entail a perceptible difference in the primary ionization. It would come to the same thing, if some one should take the data for a large number of tracks, and plot primary ionization as function of curvature: if there are really two kinds of particle differing in mass, there should be two sets of points lying along two curves, and from the ordinates of these curves at any abscissa the ratio of the masses would be derivable.

Perhaps the last sentence suggests that some one already has made this correlation, and has found that the points for all the single or penetrating particles lie upon one curve, and all the points for shower-particles and shower-producing particles lie on another. This has not been done. The reason is that many of the penetrating particles exhibit no perceptible curvature of track at all, and most of the others a very small curvature. The former are moving so fast that their momentum can not even be estimated, except as being beyond a certain critical value. As for the latter, the speeds of even these are so great as to approach the speed of light; for a given momentum-value the speed varies only a little with the mass, and the primary ionization varies too little to serve as an index of mass. To make a profitable correlation, one must use only the particles of which the tracks are notably curved. Nearly all these are shower-particles, which already are presumed to be electrons. To find a penetrating particle with a highly-curved track, one must find it when it is near to the end of its course and its energy well-nigh gone. Such is the principle which directed some of the recent successful searches for particles proclaiming themselves by their ionization to be more massive than electrons.

Before looking at the track of one of these particles, we ought to notice a couple of questions concerning ionization. One of them is: is the distinction between primary and entire ionization—or rather, our lack of perfect ability to make it in practice—likely to lead to trouble? Many observers are far from clear in reporting whether what they observe is more like the one or more like the other; but it seems probable that the second like the first is dependent only upon the speed and the charge of the traversing particle, not on the mass thereof; and this diminishes the dangers from confusing the two. The question is implicated with the second: to what extent do experiment and theory aid us in identifying the shower-particles with the electrons? As to experiment, there exist the records of a few studies made by the Wilson chamber upon particles acknowledged to be electrons, of energy-values ranging from about 2 Mev downward to some 25,000 electron-volts. In respect of the trend with energy, they agree fairly well with the assertions of the quantal theory; but when one inquires whether the absolute value for the number of clusters of ions in unit length agrees with the absolute value of the quantal expression for the primary ionization at any particular energy, one is confronted with the fact that the quantal expression contains a multiplying factor which depends on intimate details of the structure of the molecule, and is not exactly known. The quantal theory, however, predicts a minimum in the curve of primary ionization *vs.* energy, at an energy of about 2 Mev. Such a minimum (Fig. 13) was actually found by Corson and Brode in their study of some fifty particles of the cosmic rays, and probably is to be ranked as evidence for the electronic nature of these particles quite as forcible as would be an absolute agreement between the observed ioniza-

[12] Allowance being made for the relativistic dependence of mass on speed.

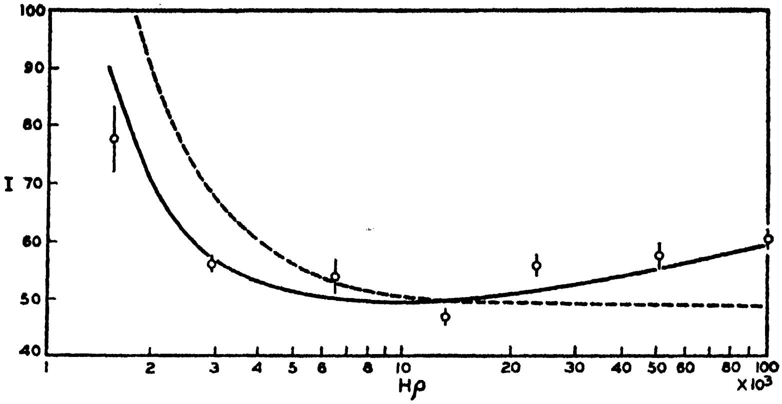


FIG. 13. IONIZATION-DENSITY (ENTIRE) ALONG THE TRACKS OF COSMIC-RAY PARTICLES, PLOTTED AS FUNCTION OF $H\rho$. THE CONTINUOUS CURVE IS THAT OF A THEORETICAL FUNCTION CONTAINING A MULTIPLYING FACTOR WHICH HAS BEEN ADJUSTED TO GET THE BEST FIT TO THE DATA. (CORSON AND BRODE.)

tion and the predictions of a reliable theory.

Street and Stevenson, with a row of counters and an interposed cloud-chamber such as appeared in Fig. 3, adjusted their counters in such a way that the chamber expanded only when the counters above the chamber had simultaneous discharges and the counter below did *not*. A thousand photographs yielded to them the track of one particle having a notable curvature and displaying an ionization six times as great as that attributable to an electron; they inferred a "mass 130," *i.e.*, a rest-mass one hundred and thirty times as great as that of an electron. Neddermeyer and Anderson transposed the bottommost counter into the very center of the cloud-chamber itself, and there it appears in Fig. 12, neatly intersected by the course of a particle which above it made a track lightly curved and thinly studded with droplets, and beneath it made a track sharply curved and densely congested. Comparing ionization with curvature along the track above and the track below, they found 240 to be a satisfactory ratio of the mass of the traversing particle to the electron-mass. Williams and Pickup, to whose technique I have already alluded (footnote 9), observed four tracks of which three were compatible with a rest-mass of about 200, the remaining one requiring a mass-value between 430 and 800. A few more such tracks have appeared in the literature, but instead of describing them I turn for the climax to another and an exacter way in which Fig. 12 furnishes the desired value of mass.

In Fig. 12, the track beneath the counter comes to a sudden end. One could take a sheet of coordinate-paper, and plot along the horizontal axis the curvature of the path as it emerges from the coun-

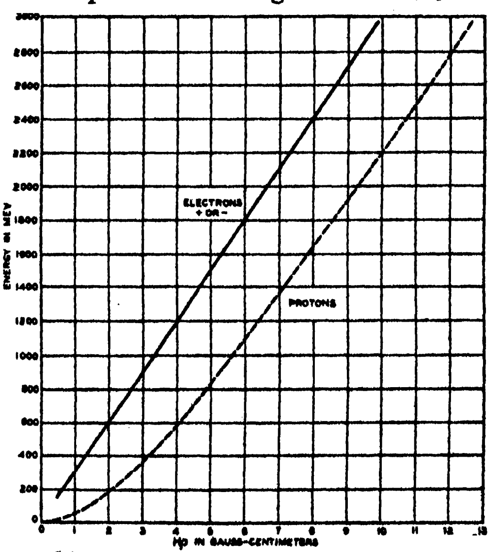


FIG. 14. RELATION BETWEEN ENERGY AND $H\rho$-VALUE FOR ELECTRONS (OF EITHER SIGN) AND PROTONS. (ANDERSON.)

ter, and along the vertical axis the length of the path from that point of emergence onward to its end. This would give a single point of what is known as a "range-*vs.*-curvature" relation or a "range-*vs.*-momentum" relation. A second point can be found by measuring the thickness of the glass counter-wall twice traversed by the particle, converting it into an equivalent thickness of gas, adding this to the length of the path beneath the counter, and correlating the sum with the curvature of the path at the point where the particle enters the counter. Now, range-*vs.*-curvature relations are among the best-studied of the features of the charged particles already known—electrons, protons, alpha-particles. These two points pertaining to the particle of Fig. 12 lie far from the curves appropriate to any of the three. An electron departing from the counter in a path of such a curvature as there is shown would have traveled 2,000 times as far before reaching the end of its course! a proton, on the other hand, only one seventy-fifth as far! This at the moment is deemed the sharpest and most clear-cut evidence for the existence of a particle intermediate in mass between proton and electron, to which Anderson now assigns a mass of 220 ($\pm$ 35) times the electron-mass.[18]

It is fitting to end this article by mention of several other kinds of evidence which have bearing on the question of the mesotron; mainly they are relatively indirect, and would require much space to describe and assess. Inferences have been drawn from the number of electrons ejected with high energy from metal plates by penetrating particles traversing these: J. G. Wilson derives a mass-value greater than 100. A curious inference has been drawn from the deflections suffered by these particles in traversing metals: the magnitude of these should by theory be independent of the mass of the particle—since it *does* appear to be the same for penetrating particles as for electrons, it is deduced that the mesotron and the electron can differ only in mass. Inferences have been drawn from the trend of cosmic-ray intensity with elevation in the atmosphere, and from the trend of cosmic-ray intensity beneath metal screens as function of the material and thickness of these last (it was thus that Auger as early as 1934 was led to suspect the existence of two kinds of charged particle among the rays).

Inferences have also been drawn from nuclear theory. To enter adequately into this difficult field is impossible here: it must suffice to say that Yukawa conceived, as a constituent of nuclear structure, of a particle possessing the charge of an electron and a mass of about the magnitude which the mesotron appears to have, and possessing in addition the quantity of *instability*. The "Yukawa particle," that is to say, has the qualities demanded of the mesotron, and in addition is liable to emit an electron; what is left behind is then a neutral particle which could elude observation. The emission is expected to follow the law familiar in radioactivity, the durations of individual Yukawa particles being distributed according to the law of chance about a mean value. Is there evidence that the mesotron behaves in this way?

For this there *is* some evidence, of the following kinds. First let us compare (in imagination) the number (per unit time per unit area) of penetrating particles flying vertically downward and the number flying obliquely downward. The comparison can be readily made with such an apparatus as that sketched in Fig. 3, the cloud-chamber being superfluous and the lead absorber reduced to the least thickness sufficient to stop electrons;

[18] Values diverging from this by more than the estimated uncertainties have been published by other observers of other particles, and may betoken an underestimate of the uncertainty or the existence of particles of several masses. A "nomograph" for facilitating the evaluation of mass from curvature of path combined with ionization-density or range is given by Corson and Brode.

the axis is oriented first at 90° and then at various lesser angles θ to the horizontal plane. Even the whole of the atmosphere is insufficient to stop such mesotrons as the cloud-chamber discloses; and yet the observations show a marked decline of the number thereof as θ decreases. But the particles which travel obliquely traverse a greater distance from the top of the atmosphere than those which come vertically down, and take a longer time in doing so; the decline of number with decrease of θ may therefore be ascribed to the perishing of the mesotrons *en route* to the apparatus as the route grows longer and longer. Second: Let us compare the effect of the obliquely traversed atmosphere with that of a sheet of lead in cutting down the number of particles arriving at the apparatus. One must make a guess as to the thickness of lead which would be required to produce a falling-off of the number of particles equivalent to that observed in the atmosphere, if the falling off were due to actual stopping of mesotrons in air and lead respectively, and the impermanence of the mesotron did not enter in at all. It is commonly conjectured that the equivalent thicknesses of lead and air would stand to one another inversely as the densities of these materials. When, however, the effects of such "equivalent" thicknesses are compared, it is found that the falling-off beyond the lead is decidedly less than that beyond the air. Now the mesotrons take very much less time for traversing the sheet of lead than the wide expanses of the atmosphere; and the "anomaly," as it has been called, is tentatively explained by assuming that few of them perish in the lead, many in the long journey through the atmosphere.

Estimates of the mean life of the mesotron thus made yield values of the order of a millionth of a second. It is supposed by many that the mesotrons are born in the upper layers of the atmosphere. Such conjectures, however, lead beyond the scope of this article, which must be confined to these few recent fruits of the seemingly exhaustless cornucopia of the cosmic rays.

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A BIBLIOGRAPHER TURNS DETECTIVE

HOW A BIBLIOGRAPHER OF FISH LITERATURE "RAN DOWN" AN OBSCURE CITATION TO ITS ULTIMATE SOURCE

By Dr. E. W. GUDGER

BIBLIOGRAPHER IN ICHTHYOLOGY, AMERICAN MUSEUM OF NATURAL HISTORY

As a professional bibliographer of fish literature, I have had from time to time the good fortune to "run to earth," in devious ways from obscure and misleading references, some very unusual and interesting things concerning fishes and fishing. And not infrequently I have been asked how I do it. For a long time I have had it in mind to describe some particularly interesting case, but always the press of work had led (if not compelled) me to let the thought pass by. However, I have just "run down" (with some expert help) the most interesting case I have ever tackled, and I am writing the story while it is fresh in mind.

For some months (since June, 1937) I have had a wonderful time studying the swordfish, *Xiphias gladius* (Fig. 1), from two points of view: its capture by the harpoon and its apparently retaliatory attacks on small boats and unprovoked ones on larger vessels. In this work I have dug up some exceedingly interesting and fascinating data. Thus Oppian (172–210 A.D.) in his "De Piscatu" published in 1478, but more accessible in the first English version as "Halieuticks or the Nature of Fishes and Fishing of the Ancients" (London, 1722), tells us that in the Tyrrhenian Sea and off Massilia (Marseilles) the fishers hunted for the swordfish in boats shaped like a swordfish—having a large ram-like prow, similar to the fish's sword, and on each side forward a large eye about where the hawse holes of a vessel are.

Now swordfish on calm sunny days delight to loaf along at the surface of the sea with the upper part of the body and particularly the sickle-shaped dorsal fin and the upper lobe of the great lunate caudal fin above water. Thus they are easily detected by the fishermen, particularly if (as is generally the case in Mediterranean waters to-day) there is in the boat a mast with a mast-head man on the lookout. In Oppian's day when a fish was detected, the boat was maneuvered alongside *Xiphias,* who was supposed to look up, and, seeing the deceitful mimic, would think to himself—"My big brother!" And then the striker would drive the cruel harpoon into his back.

This interesting procedure has been referred to by many writers on the fishing of the ancients, and has been figured by Victor Meunier in his "Les Grandes Pêches" (Paris, 1868, p. 147). Fig. 1 is a reproduction of this interesting conception of Meunier's artist.

This boat is the cleverest and most extraordinary fishing device I have found in a long study of such things. Its use seems to involve what the ethnologists call "sympathetic magic," and it would seem that this boat must have been widely used by ancient Mediterranean peoples.

Seeking confirmation of this fascinating story, I have waded through dozens of books dealing with and figuring classical antiquities, hoping to find in reproductions of Greek vases and Roman mosaics representations of such boats. But all in vain. Then with the help of the published "Bibliography of Fishes," I

began a search through the larger general works on fisheries. One of these is by S. B. J. Noël de la Morinière, and bears the title, "Histoire Générale des Pêches Anciennes et Modernes" (Paris, 1815). This I fell upon with joy, and I could hardly restrain myself when on the subject of swordfishing I read that, while it was known that the dolphin had often served the ancients as a model for their light rowboats, according to Pigafetta they had also constructed galleys in the semblance of a swordfish.

This fish (Xiphias, Espadon), which we have seen at Constantinople, has a ram (or weapon) more than a fathom long, which is shaped like the prow of a galley. The fins on each side represent the oars, and the tail the rudder. The ancient Greeks had the custom of calling the poop the tail of the galley.

Ending the paragraph, of which the quotation above forms the larger part, are the cryptic words—"Pigafetta in notis italicis ad Leonis Tacticam, 291." From this, I jumped to the conclusion that Pigafetta must have seen not only the fish but the swordfish-shaped boats at Constantinople—or at least have heard of them there. So on to Pigafetta I marched.

Now the only Pigafetta I knew of was Antonio, a Venetian patrician and knight of the Order of Jerusalem, who went with Magellan on his great voyage. After the leader's death in the Philippines, Pigafetta came home and from his daily journal wrote a narrative of the circumnavigation. Since he was a great traveler, I felt sure that Antonio Pigafetta must be the man referred to by Noël. So I hastened to the Museum library and got an English version of Pigafetta's book—without an index.

In the absence of this, I did what I have done with many other indexless books—I went through it line by line. I found statements about other fishes, but none about swordfishes nor anything about Constantinople. At the New York Public Library, a line by line search through a better edition brought exactly the same results—nil. Back in our own library in the Museum, I found the latest and surely the best English version, if not the best edition in any language, of Antonio Pigafetta's "Magellan's Voyage Around the World." This version by James Alexander Robertson (Cleveland, U. S. A., 1906) is in three volumes with a splendid index. Moreover, it is provided with a wealth of scholarly notes which are a joy to read.

In these notes there were interesting data about various fishes, and better still of boats in the Far East fashioned like a dolphin; but no swordfish, nor boats at Constantinople shaped like them—nor indeed anything to indicate that our Pigafetta had ever been at Constantinople. But behold in "note 1" a ray of light. In a brief sketch of Magellan's

FIG. 1

historian, we are warned against confusing Antonio with Marcantonio Pigafetta, author of "Itinerario [da Vienna a Constantinopoli]," Londra, 1585. Whereupon, like the New England farmer, I became greatly "het up" and set out on a search for Marcantonio that very day.

The Museum library does not have the book, nor does the New York Public Library, nor the Library of Congress, but the catalogue of the British Museum shows that that great library has it. But, alas, the book has but 141 pages, whereas my reference seems to be to page 291. But I reasoned—"Perhaps my reference is to line 291 in a chapter headed 'Ad Leonis Tacticam.'". So between the horns of this dilemma, I appealed to my friend, Dr. H. M. Lydenberg, librarian and director of the New York Public Library. He looked up the title in the British Museum Catalogue and telephoned me that he had put in an order for a microfilm of the book, "which will presently be available for your use."

Next morning, Dr. Lydenberg called again, but in a different vein, as may be gathered from the telephonic conversation.

"We have Marcantonio Pigafetta in Room 303 [Rare Books]."

"But it is not in the catalogue."

"No, it has not yet been catalogued, but as you know, in room 303 the books are arranged chronologically by centuries and are available if you know the year of publication—in this case, 1585.

"Great! Please have it got out for me that I may see it to-night."

"Since room 303 is closed at night, it will await you in room 300."

And later, hardly waiting to eat a bite of supper, I hurried down expecting to clear the whole matter up that very evening.

When I got down to the New York Public Library the book was ready for me but was in old Italian ("notis italicis"). Being obsessed with the idea that "Ad Leonis Tacticam" was a chapter heading or a marginal notation, I went over the little book page by page—with no results. Not yet discouraged, I went back next night and began a search through it *line by line*. This was slow work and I only got about half done. Another night I painfully perused the lines of the latter half. Results—exactly 0. Not yet discouraged but thinking that I must have overlooked the reference, and press of other work detaining me, I waited a week and perfectly fresh spent two more evenings with the same results. By this time I began to be considerably out of heart, but I waited another week and spent two more evenings painstakingly going over each line and noting those containing the words, fish and fisherman (in Italian), but nowhere did I find "pesce spada" (Italian for swordfish).

By this time it was clear that I was following an *ignis fatuus*, a false clue, but I determined to make one last attempt. So on Saturday afternoon, November 13, I went to the Public Library and to room 303. There the iron gate was unlocked for me and locked behind me, and Marcantonio's book was again put in my hand. I laboriously studied on every page previously noted every line containing the words for fish or fisherman. I could not translate the old Italian, but I could make out that there was surely no reference to any boats at Constantinople much less to one shaped like a "pesce spada." I was plainly following a false clue. Much discouraged, I said to Mr. Charles M. Adams, one of the curators in charge of the rare books, "I'm up a blind alley, a dead-end street, and there seems to be nothing to do but quit." And then, as sometimes happens in such desperate cases, help came.

Mr. Adams asked to see my notes from Noël de la Morinière, "Pigafetta in notis italicis ad Leonis Tacticam." To

my regret and chagrin be it confessed that, obsessed with the idea of their inclusion in Marcantonio's book, I had not critically considered the words apart and in themselves. This Mr. Adams did. "'Notis italicis' surely means notes in Italian. 'Leonis' must be the possessive case of Leo, a man's name. But what is 'Tacticam'?" A Latin dictionary gave no help. Then Mr. Adams produced Robert Watt's "Bibliotheca Britannica" and turned to the name "Leo." As I glanced down the page, I saw a Leo who was a geographer and who might have been at Constantinople. Grasping at a straw, I said "I must look through all those Leos." So I took the book, began at the head of the column, and presently the light broke through as sharp as a shaft of lightning. I read:

> Leo VI, the Wise, Emperor of the East [b. 865—d. 711].
> A Treatise on Tactics—Italice per Fil. Pighafettam, cum ejusdem Annot. Venice, 1586, 1602. 4°.

Light at last! And with difficulty did I restrain myself from upsetting the decorum of that reading room. But I did. And now I realized how absurd was my failure to translate "Leonis Tacticam" as "Leo's Tactics"—of which, however, I had never heard. Furthermore, I should have gotten a hint when in the British Museum Catalogue under Filippo Pigafetta I had read:

> Documenti . . . di Guerra . . . della Greca per M. F. Pigafetta. 1602. 4°.
> *See* Leo VI, called the Philosopher, Emperor of Constantinople.

This short title, because it did not contain the word "Tactica," did not register in the consciousness of this bibliographical detective. But the reference to "Leo VI, Emperor of Constantinople," should have sent me off full cry to the L volume of the British Museum catalogue. But, alas, I was obsessed with Marcantonio Pigafetta's travels to the city on the Bosphorus. So much for following a wrong clue.

Wringing Mr. Adams's hand *hard* for setting me on the track, and with a mounting blood pressure, I went hot foot to the catalogue of the Library of the British Museum to hunt for Leo VI, Emperor of Constantinople. But the only Leo VI I could find was the Pope of Rome. However, reasoning that Noël de la Morinière, a Frenchman, must have seen Pigafetta's book in the great Bibliothèque Nationale in Paris, I went to its catalogue with much confidence. But neither the 1586 nor the 1602 edition was listed. However, I did find editions of 1612 and 1613 done by Joannes Meursius and imprinted Lugduni Batavorum (Leyden of the Batavians—Holland).

Back to the British Museum catalogue, I hunted through *all* the Leos and presently found "Leo VI, The Philosopher of the East." Next I found not the 1586 edition by Filippo Pigafetta but one catalogued as follows:

> Leo VI, the Philosopher of the East.
> Documenti e avisi notabili di guerra: ne'quali s'insegna . . . tutta l'arte militare. . . . Redotta dalla Greca . . . par M. F. Pigafetta, con le annotationi del medesimo. Venetia, 1602. 4°.

At long last, I had the real clue in hand, and now for a transcript of the annotation.

Leo's "Tactics" had a great vogue. I have been able to trace in the catalogues of the British Museum, the Bibliothèque Nationale, the New York Public Library and the Library of Congress, 17 issues, editions and versions from 1586 to (strange to say) 1917. But when I sought the two earliest editions in the Library of Congress catalogue, I drew a blank. And so the 1586 edition not being available, but hoping that the same data might be found in the 1602 volume, on Monday, November 15, I sent a letter to Dr. Lydenberg asking him to request the

British Museum to examine the later, 1602, edition and, if Filippo Pigafetta's notes were found therein, to make and forward a photostat of the page.

However, just here, Mr. Adams did what I should have done—he wrote to the Library of Congress to ask that the book be located in the United States if possible through its tracing service. This was done and the 1586 edition was found in the library of Princeton University. A photostat of pages 292 and 293 of this book was made, sent to Mr. Adams and by him to me. Later, on a visit to Princeton, I examined this precious book and found no reference to *pesce spada* on page 291—Noël de la Morinière erred here. From this examination, it is clear that Pigafetta translated Leo's Tactics into Italian and at the end of each chapter added explanatory "Annotationi" of his own. The long-sought data are contained in a second set of "Annotationi" to chapter XVII and plainly have to do with naval matters.

And at long last, the photostat of the 1602 edition in the British Museum has come to hand. A comparison of the two photostats shows so far as page 292 is concerned the 1602 edition is a reprint, "verbatim, et literatim, et punctuatim" of the first edition.

And now for a translation. I can not read modern Italian, let alone the 1586 variety. But fortunately, to my colleague, Miss Francesca LaMonte, this old Italian is no puzzle and from her kindly made translation, the facts à la Pigafetta came forth.

It is evident that Leo's chapter XVII has to do with war galleys, and Pigafetta's notes state that there was a discussion of the origin of the galley and its beak or prow or ram. Pigafetta notes that many naval vessels are made to resemble the swordfish. "This is especially the case with the galley which both in name and form is like the swordfish (*pesce spada*) and which in Greek is called Galeotis [=Galiot]." Pigafetta states that he had seen the swordfish at Constantinople with its long sword like the beak of a galley. Then he quotes Aelian that the fish's beak was like that of a trireme, and like that of a trireme it was used to ram an enemy. "The fins which the galeote fish has placed on its body are represented by the oars of a galley and its tail by the rudder. The ancient Greeks used to call the poop the tail of the boat. Thus the parts and the name of the fish Galeotis correspond to those of the boat Galeotta."

But now that the Pigafetta reference has been run to earth, it is surprising and disappointing to find that Pigafetta did not seem to know of Oppian's story of the use of the swordfish-shaped boat for harpooning and capturing the swordfish. Of Filippo Pigafetta (1533–1603) I have been able to learn little in the bibliographical sources available to me. He was a historian, traveler and military engineer who published a book on the history and use of the compass. He was chamberlain to Pope Sixtus V and was sent by him on a political errand to Persia. He seems to have edited and published several books of travel.

Thus, after following many false clues, my search has ended successfully. It is absurd that these clues should have led me astray, but following them I have at least chanced upon sources of data bearing on the history of the development, the evolution, so to speak, of the swordfish shaped swordfishing vessel and of the long, beaked galley. I hope presently to find time to study this material and prepare a short article.

LACEWINGS AND THEIR ALLIES[1]

By Dr. LEE H. TOWNSEND
COLLEGE OF AGRICULTURE, UNIVERSITY OF KENTUCKY

THE group of insects to which the lacewings and their allies belong is known as the Neuroptera. Perhaps the most familiar of these insects to the average person are the small green lacewings which are found upon herbage and upon the foliage of trees and shrubs during the summer months. Some of these are attracted to lights and gain entrance to our homes on summer evenings.

The Neuroptera as now understood by most authorities are far different from the heterogenous group which formed the Neuroptera of Linnaeus. His group is now divided into several well-defined divisions called orders. The original name (Neuroptera) is confined to the suborders Megaloptera and Planipennia as used by Imms and by Tillyard in their text-books. Megaloptera which means "large wings" contains the alder flies and snake flies whereas Planipennia means "flat feathers" and contains the lacewings, ant lions and their allies. The latter suborder contains the greater number of species or kinds. Australia has a more complete and varied fauna of Planipennia than any other region of the earth, the only absent families being the Dilaridae and Polystoechotidae. The Neuroptera are divided by some authorities into two or three separate orders but it is difficult to find constant characters with which to support such a separation. Comstock, in his well-known text-book, limits the group as do Imms and Tillyard but he does not use the subordinal names. The larvae, or young, and adults separate very readily into the two suborders and it appears that this arrangement is a logical one.

[1] Published by permission of the dean of the College of Agriculture, University of Kentucky.

The known Neuroptera of the world represent about twenty families, depending upon the limits imposed by the different workers. Thirteen of these families are represented in North America.

The Megaloptera fall naturally into two distinct groups, the "alder flies" and the "snake flies." These are small groups and include a small number of archaic types which do not seem to be very closely related among themselves.

The alder flies include the most generalized members of the Neuroptera and are of interest on account of the large size and striking appearance assumed by some of the species. As often in primitive groups, there is only a small number of species or kinds, but they have an almost world-wide though discontinuous distribution.

The eggs of these insects are laid upon leaves, stones or other objects usually not far from water. They are generally deposited in compact masses and the number of eggs in each mass may vary from two hundred (*Sialis*) to two or three thousand (*Corydalus*). The eggs are cylindrical with rounded ends and at its free extremity each is provided with a conspicuous projecting apparatus which varies somewhat in the different groups. After hatching, the young larvae make their way to the water and according to their kind seek the muddy bottoms of ponds or slow-moving streams or maybe stones under which to hide in rapidly flowing water. All the larvae (Fig. 6) of the alder flies are predaceous, that is they devour other insect larvae, small worms or in fact any small animal life that comes their way. These larvae possess paired, lateral filaments on most or on all of the abdominal segments. Some

of the larvae (*Corydalus*) are called "dobsons" or "hellgrammites" by certain anglers who use them for bait. These larvae remain in this stage about two years and eleven months before changing to the next stage or pupa. The pupal stage occurs in the soil, moss or perhaps under the bark of a rotten log or stump near the water. Although the pupa may be buried several inches it is able to work its way to the surface so the adult may appear. In *Corydalus* the wing-expanse may range up to 150 mm.

The snake flies are the most specialized members of the Megaloptera and are entirely terrestrial in habits. This group is present on all the continents except Australia. The larvae (Fig. 10) of the snake flies (Raphidiidae) resemble very much the larvae of certain ground beetles (Carabidae) and are predaceous. They live under bark and in North America are restricted to the West. The adults are strange-appearing insects in that the region of the body just posterior to the head is greatly elongated. The fore-legs resemble the other pairs of legs and are borne at the hind end of this elongated body region, the prothorax. It is this elongated prothorax which gives these insects their common name "snake flies."

The Planipennia include the majority of the Neuroptera, and here we find the true lacewings and most of the familiar members of the order. Many of the families are very different in their adult characters, but the group is well defined on account of the universal occurrence of the piercing suctorial mouth parts in the larvae or young (Figs. 1, 2, 3, 5).[3] Nearly all the Planipennia are terrestrial insects, but a small number are more or less amphibious as larvae, and a few have truly aquatic larvae. So far as known only one North American family (Sisyridae) has aquatic larvae. These are the spongilla flies and will be described later.

So far as known all the larvae of the Planipennia are predaceous and are of importance as destroyers of aphids and other soft-bodied injurious insects. The head is generally large and freely joined to the next body division, the prothorax. Two pairs of the mouth parts, the mandibles and the maxillae, are long and exserted. The mandible and maxilla of each side form an organ for piercing and sucking. These appendages are long, sickle-shaped, sometimes armed with internal teeth, curved at the distal end and well fitted for grasping and piercing the body of the prey. The combined mandible and maxilla of each side fit together and form a tube through which the liquid contents of the victim's body is sucked. This general type of mouth parts is common to all known larvae of the Planipennia.

The larvae of the Megaloptera do not form a cocoon in which to pass the pupal or resting stage of their development but merely hollow out a cell as their place of abode for the time being. The Planipennia, on the other hand, pupate in a cocoon or covering. The silk of which these cocoons are made, in those in which the silk organs have been described, is secreted by modified Malpighian vessels and is spun from the anus. The Malpighian vessels are excretory tubules which open into the beginning of the hind intestine. The silk-organs of *Sisyra* have been described by Miss Anthony in the *American Naturalist* (1902).

The mantis-like Neuroptera or Mantispidae are among the strangest in appearance of any of this group of insects. The prothorax or second body division is greatly elongated. The remarkable forelegs are fitted for seizing prey, and in order that they may reach farther forward they are joined to the front end of the long prothorax. This is opposite to

[3] After Townsend, "Key to larvae of certain families and genera of nearctic Neuroptera." Proceedings Entomological Society of Washington, 37: 25–30, 1935. Drawings were made by Dr. C. O. Mohr, associate entomologist, Illinois Natural History Survey.

the condition found in the snake flies, where the fore-legs are joined to the hind end of the long prothorax. The adults of the Mantispidae are predaceous and the larvae, so far as is known, are parasitic. The development of these insects is peculiar in that the larvae differ in appearance at different ages. They do not merely increase in size as they grow older but the appearance changes completely. This type of growth is called hypermetamorphosis. Very little has been done on the life history of these insects, but it has been demonstrated that a European species lives in the egg-sacs of spiders of the genus *Lycosa,* while the larva of a South American species lives parasitically in the nests of wasps. Dr. R. C. Smith has reared an American species from the egg-sacs of a spider in Kansas. Not many species of this family occur in the United States and all are rare insects.

As previously stated the larvae (Fig. 5) of the spongilla-flies are aquatic. They live in fresh-water sponges upon which they feed. Excepting the alder flies and certain of their allies of the Megaloptera, these spongilla fly larvae are the only known aquatic neuropterous larvae found in North America. When full grown the larva leaves the water and on some object nearby spins over itself two cocoons of silk. One of these cocoons just covers the larva and the other is somewhat larger. The life history of two species of these interesting insects was worked out by Professor J. G. Needham in New York State.

The family Chrysopidae includes the lacewings or aphis lions, and as already stated these are probably the best known members of the group. The adults are most easily recognized by their delicate lace-like wings and their green or yellowish green color. These insects are sometimes called golden-eyed flies on account of the metallic color of their eyes in life. Some of the species when handled give off a rather disagreeable odor and have been called stink-flies, a rather unfitting name for such beautiful insects.

The larvae (Fig. 3) of these insects are known as aphis lions because they feed mainly upon aphids. They can generally be found upon plants which are infested with aphids, though they also feed upon other small, soft-bodied insects as well as insect eggs. They are somewhat spindle-shaped and have the type of mouth parts already briefly described for the Planipennia. A few species of aphis lions cover themselves with debris and are thus known as trash-carriers though most of them are naked. A trumpet-shaped structure (empodium) (Fig. 9) is present between the tarsal claws of these larvae.

An interesting fact in the life history of these insects is the way in which the female cares for her eggs. Just before laying an egg she emits from the end of her body a minute drop of a tenacious substance which she applies to the object on which she is standing. She draws this substance out into a slender thread by lifting the hind part of her body; then an egg is placed on the summit of this thread. The thread dries almost immediately and holds the egg in mid-air. The eggs of Mantispidae are also fastened upon stalks.

The cocoons are composed of dense layers of silk and are generally found on the leaves or supports of plants. Before emerging the insect cuts a circular lid from one side of the cocoon. This is done by the pupa, which crawls about for a short time before changing to the adult.

This is one of the larger families of the Neuroptera, there being about fifty species or kinds of lacewings in the United States and Canada. An attempt has been made to introduce a species of lacewing from Canada into New Zealand, where this beneficial family is absent, but as yet no information is available as to the success or failure of this venture.

The Hemerobiidae are often called

brown lacewings on account of the color of the wings of most of our species. Both the larvae and adults resemble in general appearance the Chrysopidae or green lacewings. The larvae of the Hemerobiidae, in so far as known, have the predatory type of mouthparts, already described, and feed on soft-bodied insects, especially aphids, by sucking the liquid contents of the body. The food habits are practically the same as for the aphis-lion or larva of the Chrysopids.

The name "Large Lacewings" has been applied to the member or members of the family Polystoechotidae. This family is confined to North America and excepting Sialidae contains our largest Neuropteron. The adults are very hairy, blackish and with large, broad wings. These specimens are 30 mm long to the tips of the wings and the expanse is from 40 to 75 mm.

It is strange that the larva of this large insect has never been recognized in the mature state. J. G. Needham, H. B. Hungerford and P. S. Welch have obtained eggs from females kept in confinement. Hungerford describes the eggs as follows: "The eggs are rather soft shelled and easily collapsed. While they appear chalky white to the unaided eye, under the binocular they are opalescent with a tiny chalky white button-like micropyle at one end. This characteristic reminds one somewhat of the eggs of *Chauliodes*, one of the Sialids." He further adds that the eggs are 1.02 mm long, and .48 mm wide. Welch, in his paper, gives information, not only concerning the egg, but about the newly hatched larva as well. This larva seems to be of a rather primitive type and it was most unfortunate that it could not have been reared.

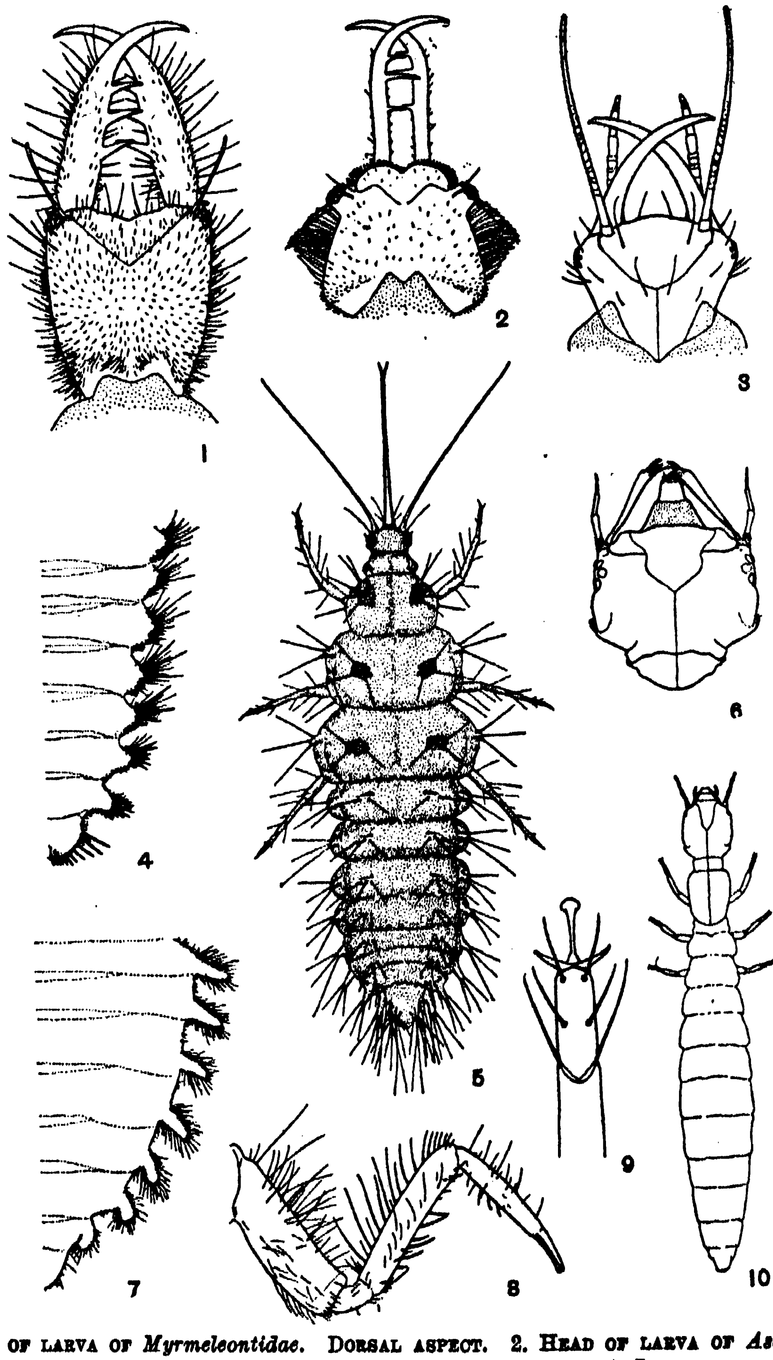
The Ant-lion Lacewings (Myrmeleontidae) are the dominant group of the order. This family is perhaps better known from its familiar larval forms, called "ant-lions" or "doodle bugs" rather than from the slender, delicate adults. The larvae (Figs. 1 and 4) are stout, with large jaws curving inwards distally and having at least three internal teeth on each mandible. Most of them live hidden in sand or debris.

These larvae are much more common in the southern and southwestern states than in the north. As the name suggests the ant-lions dig pitfalls and feed chiefly on ants. The pitfalls are usually found in sandy places which are protected from rain, as beneath buildings or protecting rocks. The larvae in making these pitfalls throw the sand out by an upward jerk of the head, which part of the body serves as a shovel. The pits differ in depth according to the kind of soil in which they are located and their sides are generally as steep as the soil will lie. When some wingless insect such as an ant steps upon the edge of one of these pits, the sand crumbles beneath it and it falls into the jaws of the ant-lion which is buried at the bottom of the pit.

The pupal or resting stage is passed in a spherical cocoon. This cocoon is made of sand fastened together with silk and is lined with the same material.

The life-histories of very few species are known. Not all the species have larvae which dig pitfalls, but these last have attracted much attention since the beginning of entomology.

The family Ascalaphidae is closely related to the Myrmeleontidae but is more restricted to tropical and subtropical regions. Both the larvae and adults of the former are larger and more robust than corresponding stages of the latter. The adults can readily be distinguished from the adults of dragon-flies which they resemble by their long, clubbed antennae. The larvae (Fig. 2) of the Ascalaphidae in common with the larvae of the ant-lion have the hind tibia and tarsus (Fig. 8) fused to form a single joint. This occurs also in the larvae of the Ithoniids and in addition these have this fusion in the first and second pairs



1. Head of larva of *Myrmeleontidae*. Dorsal aspect. 2. Head of larva of *Ascalaphidae*. Dorsal aspect. 3. Head of larva of *Chrysopa*. Dorsal aspect. 4. Right half of abdomen of larva of *Myrmeleontidae*. Dorsal aspect. 5. Entire larva of *Sisyra* sp. Dorsal aspect. 6. Head of larva of *Corydalus cornutus* Linn. Dorsal aspect. 7. Right half of abdomen of larva of *Ascalaphidae*. Dorsal aspect. 8. Right metathoracic leg of larva of *Myrmeleontidae*. 9. Tarsus of larva of *Chrysopa* sp. 10. Entire larva of *Raphidia* sp. Dorsal aspect.

of legs as well. In general appearance the larvae of the Ascalaphids and Myrmeliontids are much alike. The head (Fig. 2) of the former is much broader and the abdomen (Fig. 7) has laterally produced segments. The body setae are short, stubby and longitudinally fluted in the Ascalaphids but are long, slender bristles in the ant-lions. Some species of Ascalaphids lay their eggs in regular rows on plants. In these, certain structures which are really imperfect eggs are placed as blockades around the stem below the eggs and have been regarded as a protective device. The larvae lie in wait for their prey and normally walk forward though they can also walk backward. The older larvae may turn cannibal and eat their own brothers.

The Ascalaphid larva when full-grown spins a spherical cocoon more or less covered with bits of leaves and twigs. The adults are crepuscular.

The family Coniopterygidae includes perhaps the smallest of the Neuroptera. They are rather fragile insects and bear a general resemblance to aphids. The body and wings are covered by a whitish powder. The wing venation is quite simple, being greatly reduced as compared with other Planipennia. The adults resemble slightly other neuropterous insects but the strongest claims which these insects have to be considered neuropterous are the structural characters of the larvae.

The larvae feed upon aphids, scales and probably other such small creatures. They are short and taper towards the hinder extremity. The mandibles and maxillae are short, stout, piercing organs and the labial palps are prominent, flattened appendages which project in front of the head. The larvae pupate in a cocoon spun of silk emitted from the anus as in other Planipennia. The members of this family, all of which measure 3 mm or less, are not rare but need careful looking for and, up to the present, only about eight species have been found in North America.

So far all the groups that have been mentioned have been found in North America. Not necessarily there alone, but at least they are native with us. Now will be mentioned briefly several families which are not present in North America but are especially interesting.

The Ithonidae or Moth-Lacewings is an interesting neuropterous family in that it more nearly bridges the gap between the Megaloptera and Planipennia than any other known family. This family is confined to Australia, as are several other groups of very interesting animals. The males have large, forcipate appendages, while the females are larger and carry a peculiar sand-plough for use in laying their eggs in sandy soil, rolling each into a small cocoon of sand-grains. The larvae resemble white grubs but have strong burrowing legs. They emit a pleasant odor of citronella. They attack Scarabaeid larvae and other insect grubs in the soil with their short, upcurving, sucking jaws. These larvae probably have some economic value, but attempts to introduce them into other countries have so far failed.

The Psychopsidae or Silky Lacewings is a family of very beautiful insects which has existed almost unchanged since Triassic times, and with its headquarters in Australia. A few species occur also in Africa, India and China. Most all the species are of striking beauty.

An extraordinary group of lacewings is the family Nemopteridae. The head is prolonged forwards into a rostrum, the only family of the order which shows this character. The hindwing is remarkably specialized, being long and narrow. This wing is either ribbon-like, or with one or two expanded parts, more or less spoon-shaped. The forewing has much the Myrmeleontid type of venation. The larvae

live in sand or debris, have a stout body and a long slender neck. Their jaws may or may not have internal teeth. This family is confined to Africa, Madagascar, South Europe, India and Australia.

The larvae of the family Osmylidae live under stones, about moss or some other situation either in or near the water. These larvae have long stylet-like mandibles and maxillae which curve slightly upward. Unlike *Sisyra,* already mentioned, they have no gills but breathe by means of thoracic and abdominal spiracles. It has been reported that the natural food consists of dipterous larvae. The adults occur along the borders of clear streams where there is a dense growth of bushes.

There are several excellent examples of sexual dimorphism in the Neuroptera. The dimorphism referred to here is a structural difference between the sexes other than that concerned in the genitalia or external sexual parts.

The male *Corydalus* has enormously elongate, sickle-like mandibles. The female resembles the male in most respects but her mandibles are comparatively short.

In the lacewing *Meleoma signoretti* there is a striking sexual dimorphism. The head of the male bears a prominent frontal horn, and this supports a brownish, ventral brush of hair.

The members of the genus *Psectra* of the Sympherobiidae are of interest in that the female has the usual four wings whereas in the male the hind wings are atrophied. Each wing is represented only by a small scale.

The only North American species of Dilaridae, *Dilar americanus,* has a male of which the antennae are pectinate. It is interesting to note that the female is furnished with an exserted ovipositor, the length of which is a little greater than the length of the body. This same statement applies to the female of the Raphidiidae or "snake flies."

It is obvious that throughout this discussion emphasis has been placed on the larval stages. The habits of these larvae or young are most interesting, living as they do in a variety of situations. Their place of abode includes various habitats from water to the egg sacs of spiders. About the only thing all have in common is the carnivorous habits. So far as known this holds true for all larvae of the order.

In so much of our entomological work the emphasis has always been on the adult stages. True there is much here to be done but the immature stages of practically any group of insects offer a fruitful field for investigation.

Knowledge gained from a study of the immature stages of any group of insects would probably shed light on the classification and grouping of the adults. In no group is this better shown than in the Neuroptera. So far as the larger groups such as suborders and families are concerned the larvae furnish better characters for separation than the adults. At the present time the classification of the order is based very largely on wing-venation and this does not always hold. For example based on wing-venation the small family Coniopterygidae could hardly be placed in the Neuroptera at all. It is often stated that the larval characters enable this family to be placed in the order under discussion.

Notwithstanding the way in which the Neuroptera of the Linnaean classification has already been divided as mentioned in the early part of this discussion, some authorities claim that even yet the Neuroptera represent several lines of evolutionary descent from the ancestral stock whatever that was. It is easy to see that this order exhibits at least two distinct lines of evolution. Going back to the undifferentiated ancestors of the order, one branch arose and made up the suborder Megaloptera. This is divided into two well-marked families, the "alder-flies"

(Sialidae) and the "snake-flies" (Raphidiidae). The chewing mouth-parts of the larvae (Figs. 6 and 10) better characterize this suborder than any characters of the adults. The Sialidae is certainly the more primitive. Some authorities are of the opinion that each of these families should be placed in an order to itself.

Another line of evolution leads to the suborder Planipennia and thus to the greater number of the Neuroptera. The various members of this suborder exhibit many and varied characters but so far as known all agree in that the larval mouth-parts are constructed on the same plan (Figs. 1, 2, 3 and 5) and no maxillary palps are present. The details and shape of the mouth-parts may differ somewhat but in no other group of insects is the channel through which the liquid food is taken into the body composed of the combined mandible and maxillae. This type of mouth-parts has already been briefly described.

The larvae, so far as known, of both suborders separate readily into families. Characters for the recognition of species may not always be available among the larvae but this should in no way detract from their value in diagnosing larger categories.

It is the hope of the writer that he has helped to demonstrate the importance of the immature stages in a classification of insects, by the example of the Neuroptera. He does not advocate basing a grouping on the larvae alone, but is of the opinion that they might aid in many cases.

CAUSES OF VIRUS DISEASES IN PLANTS

By Dr. MELVILLE T. COOK

PLANT PATHOLOGIST, AGRICULTURAL EXPERIMENT STATION, RIO PIEDRAS, PUERTO RICO

THE progress in our knowledge of any science or branch of science goes through an evolutionary development which is as interesting as the evolutionary development of any group of animals or plants. When this occurs within the lifetime of a generation it becomes especially interesting to the research students of that period. This is true of the advancement of our knowledge of the viruses that cause diseases in plants, and which has come to our knowledge within the last half century. The studies of these diseases, like all other studies, have been greatly influenced by the progress in other sciences. Although a few of these diseases have been known for a very long time, the research studies were started by Mayer a little more than a half century ago and the first paper on this subject was published by him in 1882, although the most important paper was not published until 1886. Mayer was evidently influenced by the science of bacteriology which was attracting so much attention at that time. His studies were made on the mosaic disease of tobacco which had been known for some time and which was the first of the virus diseases to be recognized as of great economic importance. He appears to have been convinced that this disease was caused by bacteria, although he did not succeed in isolating an organism. Dr. Erwin F. Smith, who contributed so much to our knowledge of bacteria as the causes of diseases of plants, was studying the yellows disease of the peach in the United States at about the same time that Mayer was studying the mosaic disease

of tobacco, and in his first paper, published in 1888, he said:

> The spread of yellows from diseased buds to healthy stocks, which I have carefully verified, points strongly to some contagium vivum as the cause of the disease. If a micro-organism be really the cause, it probably occurs quite constantly in some part of each diseased tree, and this must be established beyond question; it must also be clearly distinguished from similar organisms not related to the disease; and, finally, it must be isolated by cultivation in suitable nutritive media and be able to produce the disease when inserted into healthy trees. If from a pure culture of some micro-organism peach yellows can be induced in healthy tree, then the case is closed and there can be but one verdict.

Iwanowski (1892), who also studied the mosaic disease of tobacco, believed that it was caused by bacteria. He discovered that the active agent would pass through a Chamberland filter but was so firm in his belief that the causal agent was a bacterium that he did not understand or appreciate the importance of this discovery, which was to attract so much attention in future years. He believed that the disease was caused by an organism which was so small that it could pass through the filter.

Beijerinck (1898) was the first to oppose the bacterial theory. He confirmed the filtration experiments of Iwanowski, but insisted that the liquid which passed through the filter did not contain bacteria. As a result of these studies he advanced his theory of a "contagium vivum fluidum" which lived parasitically in the cells of the host plant.

Iwanowski published another paper in 1903 in which he opposed the work of Beijerinck and insisted on the bacterial theory.

The bacterial theory has persisted with greater or less vigor for many years and has come forward in many papers, but has been surrounded with doubt since the work of Beijerinck. His "contagious living fluid" theory offered a very ingenious explanation of the increase of the causal agent but was not accepted by many students of the problem. However, this theory had its influence on the studies and literature and as late as 1925 Kunkel said:

> From this brief consideration of the hypotheses it is seen that we do not yet possess a better one than that which assumes a living fluid contagium. When Beijerinck formulated his conception he believed that the virus of tobacco mosaic could pass to some depth into solid agar plates. We now know that he was in error in this respect. The virus does not pass through the agar. We are therefore led to believe that the causative agent although filterable is nevertheless corpuscular. Beyond the fact that they are filter passers we know little about these corpuscles. They are doubtless very minute but perhaps not ultramicroscopic. Plasticity rather than size may account for their filterability.
>
> It would be folly to speculate as to what these corpuscles are like, but I wish to suggest that they are probably of the nature of living cells.

The next was the enzyme theory, which was advanced by Woods (1899) and Heintzel (1900), who developed this theory independently. By this time the study of enzymes was attracting much attention among the research students of the biological sciences, and Woods was evidently influenced by these studies. His idea as to the origin of the active agent appears to be expressed in the following statement:

> It is evident, therefore, that the zymogen exists in the cell in sufficient quantity to regenerate practically the same amount of active enzyme as is already in the cell. The transformation of the zymogen into the active enzyme takes place whenever the active enzyme in question is removed or destroyed.

This theory was very generally accepted by many students and has had a marked influence on the studies of these diseases for many years. However, it was questioned by several students, especially by Allard (1912–15), who said that the "facts strongly suggest the presence of a living active microorganism."

Hunger (1902–1905) opposed the enzyme theory and advanced the theory of

a "non-living toxic ferment" which was always present in healthy plants and which increased when the conditions were unfavorable for the nutrition and growth of the plant. This theory assumed that the ferment was the product of the plant cell. It did not attract much attention or receive much support.

Before leaving the enzyme theory it is interesting to note that Penhallow (1883) reported that peach trees infected with yellows contained more enzyme than healthy trees, but it is evident that he confused yellows trees with frost-injured trees.

Mayer (1886) said that:

A chemical ferment seems probable. This sort rarely causes a disease, and it is unheard of that an enzyme multiplies for itself. An organized ferment might be a fungus or a bacterium.

Protozoa-like bodies, often referred to as inclusion bodies, intracellular bodies and X-bodies, were known long before the development of the protozoan theory. Iwanowski found them in the cells of mosaic tobacco plants in 1900, but believed them to be the results of the disease. Delacroix reported the results of some studies on these bodies in 1906, and Lyon described similar bodies in sugarcane infected with Fiji disease in 1910. However, no one suspected similarity between the tobacco mosaic and the Fiji disease, and these bodies did not attract much attention until 1921, when Kunkel published a paper in which he described intracellular bodies in the chlorotic areas of mosaic corn and suggested that they were living organisms and the possible causative agents of the disease. This paper led to studies on several of the virus diseases and to the discovery of similar bodies associated with several of them. During this same period flagellate-like bodies were reported associated with several of the virus diseases. The fact that protozoa are known to be the causal agents of many diseases of animals, including man, influenced and stimulated these studies. However, these bodies could not be found associated with all types of virus diseases, and the theory was questioned by many research students. At the present time we do not have any positive evidence that these bodies are the causes of diseases, but their presence in a diseased plant is considered positive proof of a virus disease.

The virus theory, unlike the other theories, can not be very definitely associated with any one worker. The term "virus" is from the Latin and originally referred to a poison, but has lost this meaning in relation to this group of diseases. It has been used by the medical profession for many years in connection with smallpox and other diseases. Baur (1906) expressed the belief that the causal agent was a non-living, highly organized product of metabolism which he called a "virus." So far as the writer has been able to learn, Baur was the first to use this term to designate these diseases. The term was used with variable meanings during the next few years. Some workers assumed that it was a living organism, an ultra-microscopic organism or a something made up of inconceivably small particles. In fact, the students accepted the name "virus" for an active, causal agent which they did not understand, and the research studies were directed at the determination of the characters and properties of this agent. This resulted in studies on dilutions and on reactions to temperature and chemicals which contributed much to our knowledge of the subject but did not give a very definite explanation as to the causes of these diseases which were attracting more and more attention. We are now using the term "virus" with a meaning entirely different to that in which it was originally used, and it will probably persist as a name for these

The behavior of the viruses was so

similar to that of living organisms and the reactions of the host plants so similar to the reactions of plants attacked by living organisms that many of the workers had come to consider these so-called viruses as living organisms. Of course it should be remembered that nearly all the students of these diseases had been trained in the biological sciences and very naturally assumed that these diseases were caused by living organisms and directed their research studies accordingly.

However, there were some workers who questioned the living organism idea, and these doubts gave rise to studies which resulted in the chemical theory. In this connection we should remember the theories advanced by Woods, Hunger and Baur to which we have referred. The chemists who have done so much during the past ten or twelve years to advance our knowledge of this subject were not influenced by the living organism idea that had influenced the biologists. They attacked the problem from an entirely different view-point. Vinson and Petri (1927–1934) published the results of studies in which they had precipitated a substance from the juice of mosaic tobacco by the use of safranin and other chemicals. This substance would produce the disease when injected into healthy tobacco plants. These precipitates were not pure, but contained traces of nitrogen. Barton-Wright and McBain (1933) gave us the results of studies on the mosaic tobacco plants by which they had isolated a white crystalline compound without nitrogen which would also produce the disease when injected into a healthy tobacco plant. Caldwell (1934) published the results of studies in which he followed the methods of Vinson and Petri and of Barton-Wright and McBain and said, "I have found no evidence that the crystals contain virus except as an impurity."

The studies of these research students were followed by a series of papers by Stanley from 1934 to the present. He was able to isolate a protein crystal which proved to be extremely virulent when injected into healthy tobacco plants. These crystals were prepared first by the use of chemicals and later by the use of ultracentrifuge. Similar results have been obtained in the studies of some of the other viruses of both plants and animals. These protein crystals appear to be produced autocatalytically in the cells of the host plants, to possess a high molecular weight and are extremely variable in stability.

The recent studies which have given rise to the chemical theory call to mind that Iwanowski found crystals in the cells of mosaic tobacco plants and that the description of the active agent of tobacco mosaic written by Beijerinck is exceptionally good. They also call to mind that Woods, Hunger and Baur believed the active agents of tobacco mosaic was produced in the cells of the host plants. However, there are some workers who believe that the cells of the host plants produce the active agent as a result of stimulation.

Stanley from the very first has admitted the possibility of the protein crystals being carriers of an active agent and in 1938 said:

> The possibility that the activity may be due to an impurity must always remain, regardless of the material under discussion. However, since there is no reason to believe that such a situation actually prevails in the case of the virus protein, we are unable at the present time, to conclude other than that the high molecular weight protein under discussion is the virus. Now these same tests that indicate that the virus protein is homogenous may be used to demonstrate that it possesses the ordinary properties of molecules. As a matter of fact, the chemists, after a perusal of the physical and chemical properties of the tobacco mosaic virus protein, has no difficulty whatsoever in coming to the conclusion that despite its huge size, it has all the properties of a molecule and hence is a molecule.

Bawden and Pirie (1937) isolated liquid crystalline nucleo-proteins from tobacco mosaic and two cucumber mosaic viruses, which indicates that they are the same or very similar to the nucleo-proteins obtained from nuclei. This has been confirmed by other workers and raises the question as to the relationship between a virus and a gene.

It has been suggested by Green and later by Gortner that a virus might be an internal parasitic organism that has lost its power to produce protoplasm but persists as nuclei living in the protoplasm of the host cell. If this theory is correct, it is very easy to account for the fact that the virus is restricted to the cells of certain plants and for the mutations which have been reported for a few viruses.

We should not close this review of the subject without calling attention to the gene theory which was suggested by Duggar and Karrar (1923), who said that a virus might be:

> . . . a particle of chromatin of some structure with a definite heredity, a gene perhaps, that has, so to speak, revolted from the shambles of coordination, and being endowed with a capacity to reproduce itself, continues to produce disturbances and stimulation in its path, but its path is only in the living cell.

Lesley and Lesley (1928) reported a wiry tomato which resembled a mosaic tomato and said that "it is hereditary in nature and probably due to a gene mutation."

Holmes (1934) reported experiments with *Capsicum* and *Nicotiana* which indicated that a single dominant gene was responsible for the localization of tobacco mosaic virus.

Riddle (1936) called attention to the fact "that both the virus molecule and the genes are known to have the capacity to duplicate themselves exactly." He also stated that "there is strong evidence that the gene is a single molecule and that it is a protein molecule."

Kostoff (1936) made a very interesting comparison of a virus and a gene and concluded by saying:

> Some of them coincide, others are similar and some others somewhat different. It is very unfortunate that we do not yet know such essential characters according to which we can definitely establish the degree of relationship between genes and viruses. Until that time we have no right to claim that genes are identical with viruses. It is better now to leave this question open, instead of drawing conclusions. We can only say that in many respects the effect of the virus is similar to that of the gene.

McKinney (1938) said:

> It is possible that the virus represents a filterable form of some larger organism, or it may represent a degenerated organism which has retrograded by a series of mutations to a stage where a few genes or perhaps a single gene remains to perpetuate as virus.

Holmes (1937) reported four types of symptoms on *Capsicum frutescens* when infected with tobacco mosaic virus, distorting strains which he believed were controlled by three different genes.

All these theories have had their supporters, but no one of them has been accepted by all the workers, and it may require several years to demonstrate that any one of them or some entirely new theory is correct.

CHLOROPHYLL—ITS FUNCTION

By Dr. FRANK MILTON SCHERTZ
WASHINGTON, D. C.

Ever since man has had the power of sight he has known that Nature annually paints the surface of the earth green. Nature's annual paint bill includes roughly two thousand million tons of green pigment and 300 million tons of yellow. The function of these two and a third thousand million tons of colored organic plant material has long been the concern of scientifically minded men.

As scientific thought has progressed, man's conception of the rôle of these green and yellow pigments has undergone change, and the change has been in proportion as he has gained knowledge regarding the other processes of nature. For no part of man's conception of life and of living things can proceed without deeply affecting his other conceptions of the nature of himself and of the physical world. In our time there have been vast changes in man's conceptions of the physical universe. These conceptions in turn are bearing fruit by affecting our other interpretations of life. In troubled times like these man is in need of new ideas, new conceptions and a new manner of life.

A study of the chlorophyll problem offers numerous possibilities, and it is these possibilities that are worthy of our serious consideration. Test-tube experiments concerning these pigments are highly interesting to scientific investigators, but thoughts concerning these pigments become of vastly greater interest when these thoughts begin to take on aspects that affect man's conception of his universe. They lead to enlightening knowledge which tremendously affects his own future.

With these thoughts in mind let us turn to our subject, which at present is only in an evolutionary state of development. If we have learned how very little we really know then we truly have accomplished something. It is that little that we know which is to be given consideration here.

We are aware that in some way chlorophyll is bound up with energy and with light and that it has something to do with the production of organic matter. Investigators of high ability have been deeply interested in the numerous processes which are continuously involved. Many conflicting theories have resulted from these investigations. The present situation is remindful of the confusion that, in a past day, arose around a structure which was being erected by the descendants of Noah, in the land of Shinar.

A complete history of man's ideas concerning the nature and the function of chlorophyll would prove highly interesting, but we have space only for a brief consideration of the most important recent advances in our knowledge. Regarding the history of our knowledge concerning the function of chlorophyll, it is sufficient to say that prevailing ideas and conceptions concerning its nature were largely worked out before we knew anything at all regarding the chemical nature of the pigments involved. We had the problem solved before we even knew the fundamentals. In other words, we had the problem solved years before we knew the complete nature of the problem which was ours for solution. New ideas which were developed were made to fit into an attempted explanation rather than made to assist in explaining a complicated process which was difficult to understand. Thus, rather than serving to clarify the picture, our ideas only clouded that which

we sought to understand. So we must become again as little children and seek to understand the glories of the heavens and the wonders of our earth and their interrelationships.

Chemists have been leading the way by rendering valued assistance in untying the Gordian knot which has been so skilfully tied by nature in such a complicated manner. Exactly one hundred years ago, this year, Berzelius first sought to understand the chemical nature of chlorophyll. The problem was beyond the available methods and technique of his day. While his conclusions regarding the nature of chlorophyll were largely different from those of our time, his objective was correct.

Forty-one years later Hoppe-Seyler, using improved methods, made an attempt to isolate chlorophyll. His experiments likewise were not successful. Chemical workers then for many years made no further attempt to isolate the green pigment, for the task appeared hopeless. Chlorophyll was discovered to be easily altered, it was chemically indifferent and extremely soluble, especially when mixed with so many impurities. These difficulties made the isolation of the pure pigment appear insurmountable.

By carefully studying the published works on chlorophyll and with the aid of many new experiments, Willstatter[1] largely deduced the characteristics of its constitution from a consideration of its derivatives that were formed from its reaction with acids and alkalies. So perfect were his deductions that when the preparation of the natural pigment was finally accomplished in a pure state, nothing new was learned from its analysis. Pure chlorophyll was found to have six important characteristics, and all these were fully known before the pure pigment was isolated in 1911.

We have here a deductive method which was used to accomplish that which could be accomplished in no other way. Finally, because of the knowledge gained, the impossible became possible and pure chlorophyll was isolated. Preparations which were made, using new methods, fulfilled the six characteristics laid down by Willstatter. His analytical data have been supplemented and improved by means of new preparations.

Using Willstatter's deductive methods and making use of published information which bears on the chlorophyll problem, we should be able to figure out some important characteristics of the function of chlorophyll—a problem which because of its intangibleness is difficult of solution.

Not a single investigator will question the statement that chlorophyll has something to do with energy and light and with the production of our foodstuffs. These are our gospel truths. The health-giving properties of chlorophyll and the substances which accompany it are also being established. Chlorophyll and its accompanying substances are intimately associated with health and with life.

Only eleven years ago, both Conant and Fischer began chemical investigations on chlorophyll. These investigators have established the complex chemical nature of the chlorophyll molecule. The chemical composition of chlorophyll, as given by Willstatter, has been wholly substantiated and the finer details of the molecule have been worked out. The Küster structure for the arrangement of the pyrrole nuclei has been approved.

These workers have shown further how closely the chemical make-up of chlorophyll approaches that of hemin. As work has progressed, chemical investigations have shown that the chemical make-up of these two prominent substances is almost identical. Both are complex porphyrin compounds. Their work has been such that they have made porphyrin chemistry a most vital part of all living things, plants and animals. Porphyrin chem-

1 Willstatter and Stoll, "Investigations on Chlorophyll." Trans. by Schertz and Merz. 385 pp. 1928.

istry is such an inviting subject that Fischer[2] in his laboratory is carrying on investigations as to the nature of the porphyrin complexes which are present in the lower plants and in bacteria.

The chemical nature of these pigments is such that Emma M. Dietz[3] has seen fit to make the following statement: "In the slow development of the chemistry of these two pigments, it has been an increasing source of wonder to chemists to find that two substances of such widely different origin and function are yet so remarkably similar in structure."

Chemical investigations completed since 1900 have revealed the close chemical relationship of chlorophyll and of hemin; they have established porphyrin complexes as a vital part of living processes; and they have caused chemists to wonder about the origin, the structure and the function of these remarkably similar substances. The chemist has given to us the finer details of the structure of the hemin and the chlorophyll molecules, and he has further revealed to us their wide distribution in nature. In fact, many hundreds of complex porphyrin compounds have been prepared in the laboratory, but not one of these is to be found occurring naturally in plant or in animal life. This fact suggests to us that something vitally different is going on in the cell from that which is being accomplished in our test-tubes. Our chemical laboratories have proven that chlorophyll and hemin are built on the same structural plan, but they have offered little as to an explanation of the life processes which involves these pigments. It is possible that some of our ideas of chemistry have been actually blinding us as to what is going on in living cells. Studies in this field should reveal some of the characteristics of the function of chlorophyll. The facts are, we know a lot about what the chemist can make out of chlorophyll, but our question is, "What does nature make using chlorophyll?" Chlorophyll, hemin, powerful catalysts as catalase, peroxidase and cytochrome C are all naturally occurring porphyrin complexes, and a study of them should assist us in a solution of our problem. Traces of porphyrins are widely distributed in nature, but as yet their biological function is unknown. The rôle of this type of molecule in natural processes needs investigation. Chemical investigations on chlorophyll and on hemin have not answered the question how plants take up carbon dioxide and form our foodstuffs, but they have shown us that plants and animals have something fundamentally the same in their make-up. Perhaps one of the characteristic functions of chlorophyll is also a characteristic function of hemin.

Recent studies on chlorophyll enable us to further observe that even a more close relationship exists between hemin and chlorophyll. Man long has known that hemin is only part of a large functioning molecule. Four molecules of the red brown pigment, heme, are attached to a colorless protein (globin), and the complex is known as hemoglobin. In the case of chlorophyll, the picture is not so well defined, for very recent research has revealed a similar state or condition for chlorophyll. Smith[4] has prepared aqueous solutions of chlorophyll which show characteristic protein properties. These pigmented solutions resemble the pigment as it exists in the leaf. Carotenoids are believed to be associated with this chlorophyll complex. This chlorophyll-protein complex has been given the name of "Phyllochlorin," which is analogous to hemoglobin. Ten years ago, Lubimenko[5] has stated that natural chlorophyll is not a simple mixture of green and yellow pigments, as is generally believed, but it is a colorless albuminoid,

[2] Hans Fischer, *Chem. Rev.*, 20: 41–68, 1937.

[3] Emma M. Dietz, *Jour. Chem. Ed.*, May, 1935. Pp. 208–216.

[4] Emil Smith, *Science*, 88: 170, 1938.

[5] Lubimenko, *Rev. Gen. Bot.*, 40: 415–17 and 486–512, 1928; also, *Chemical Abstracts*, 22: 3906.

giving an aqueous colloidal solution which breaks up on coagulation to form colorless protein and the pigments. Thus daily, the picture for chlorophyll is becoming more like unto that for hemin. Both pigments in their natural state are part of a protein complex. Perhaps, after all, their functions may not be as dissimilar as we have been leading ourselves to believe.

There is a growing awareness that something besides the chloroplast pigments is deeply concerned in the production of our foodstuffs. Unsupported theories have existed merely because there has been no other plausible explanation. Investigators[6] now are studying organic compounds with a view to better understanding the metabolic processes which are fundamentally concerned with the primary stages of carbon dioxide absorption.

The matter of carbon dioxide absorption is an open question. It might be appropriate to open again the question of oxygen in its relation to hemoglobin. Only two years ago an investigator[7] has sought to know why nature chose a molecule with a molecular weight of 68 thousand to transport oxygen with a molecular weight of 32. He also has asked why nature has chosen a colored pigment for this purpose. These questions being asked regarding hemoglobin are in perfect harmony with doubts we all hold concerning our own past ideas regarding chlorophyll. Perhaps a solution of questions regarding one of these pigments will aid in solving questions regarding the other. Questions can not be raised regarding chlorophyll without at the same time raising questions regarding the function of hemoglobin.

Returning again to our gospel truths, it is known with certainty that hemoglobin and phyllochlorin are intimately associated with light. Both animals and plants respond wonderfully well to light factors. Both need sunshine and both use sunshine. These are facts, but the how and the why have never been very satisfactorily explained.

The characteristics of the function of chlorophyll, which I have named, point to but one conclusion, namely: that chlorophyll is a pigment which nature has given to plants as a means of absorbing energy in the form of light. In other words, when chlorophyll was given to our earth, living processes could then proceed at a tremendously accelerated rate. Undoubtedly, in our present scientific literature, all the characteristics of the function of chlorophyll—and of hemin also—are to be found. The difficulty which confronts us is our own inability to recognize them. If only for a second we could be permitted to get a glimpse of the natural function of chlorophyll, then we could turn the pages of our recorded scientific endeavors and rapidly assemble the attributes of the function of this compound, as it actually exists in nature, rather than as it exists in the minds of a single created species.

Since we are not permitted even a glimpse of a second, then let us humbly presume that we know the function of chlorophyll, and assemble some of its attributes. By assembling what is even now in the literature, it is possible for us to conceive of chlorophyll as being nature's means of converting energy to matter. Undoubtedly chlorophyll has no monopoly on this function, for all chemical substances are known to absorb rays from one portion of the spectrum or from another. Plants and animals, then, which are large absorbers of portions of the spectrum become nature's prime energy converters.

In nature's scheme, then, plants and animals can be placed in a single category, while man for convenience has placed 250,000 species in one class and

[6] Kenneth Thimann, *Science*, 88: 506, 1938.

[7] *Science News Letter*, p. 70, Aug. 1, 1936.

950,000 in the other. All these 1,250,000 species are coworkers with nature in accomplishing her end—that of making earth substance from energy.

If nature is producing earth substance from energy, using living things as transformers, then we can look forward to the realization of the alchemist's dream, in the leaves of plants, where these forces are most active.

Under this scheme of things, creation then is continuous and eternal, for that which gives and sustains life is continuously flowing to our earth and to all living things. Creation then is greatest where life is most lived—where the species population is most dense. The stuff of which we have been made is here now and we are a part of it, but the essence of the stuff of which we are being made and of which our children and our children's children will be made is yet to come. Man is something far more than mere dust, for he is continually partaking of the spirit of creation.

In conclusion, let me say that in interpreting chlorophyll as I do, I am simply attempting to solve problems which are most intimately associated with my own field in which I have studied for more than twenty years.

Problems which are fundamental can be solved when and only when we dare to think differently than men have thought heretofore, and the more fundamental the problem the more we will have to reshape our own thought processes. Nature's processes are going on everywhere in and about us, the same as they have been for more than a billion years. These we can not change, but we can change our conception of the processes involved, and that is the function of science and of scientific men. When we have changed our fundamental conceptions of the processes involved we have then placed ourselves in a position where we can reshape the future of all nations and of all men. It is the truths of life that we seek and when these are known, upon this structure, we can begin to build a more ideal civilization.

A COMPASS FOR MANKIND

By D. S. BURCH
WASHINGTON, D. C.

WITHIN the United States there is a secondary "population" much greater than the number of people whom we commonly consider to be the principal inhabitants of this country. The secondary population has no accumulation of serious problems. There is no material unemployment. There is no crime worthy of mention. The health status of this secondary population is good—and constantly improving. Each succeeding generation is better physically than the preceding one.

This is not a fanciful social order. It is real and tangible. And in it may be found the counterpart of scores of human problems with keys to the proper answers. As you may have surmised, this secondary population is the nation's vast aggregation of domestic animals.

KNOWLEDGE FROM JUNGLE BEASTS

From primitive times man has learned much to his advantage from animal life. He followed the trails of wild creatures to find water holes and food in the jungle. At Versailles early in the study of aeronautics, man sent a sheep, a duck and a cock aloft in a balloon as the first aerial travelers—and not until he got them back unharmed did he himself ascend in search of the secrets of the upper air. In more recent times man has gained much of his medical knowledge from the reactions of

animals. And when in need of adrenalin, pepsin or other glandular extract, he has no compunctions about taking his supply from an animal source—not to mention many articles of food and clothing also. None of this experience has made man any the less human, but on the contrary has been a vital power for his comfort and welfare. And what now can be more natural or sensible than to study animal life from social and economic angles to glean from it new and profitable applications.

First, it is noteworthy that the United States Government, through its Bureau of the Census, thinks enough of the nation's cattle, hogs and sheep to count them every five years, whereas it gives the human population a thorough count only every ten years. The last animal census, in 1935, showed the total number of live stock and fowls to be well over half a billion head. The welfare of this vast animal aggregation is nominally in charge of a cabinet member, the Secretary of Agriculture. But by act of Congress back in 1884, which created the Bureau of Animal Industry, most of the federal supervision of farm animals was assigned to that unit. There is cooperation with other branches of the federal establishment and also with states, but the chief responsibility has gravitated to the bureau mentioned. Its chief, Dr. John R. Mohler, holds high command over this great animal empire and has done so continuously since 1917.

Race Improvement

In any effective effort to bring about real and lasting betterment of the human race, we must not be squeamish about admitting that man is an animal—a highly intellectual one, a refined one, but still an animal. And the operation of heredity in the human family parallels that of the lower animate species. But while spokesmen for human welfare have been debating the sterilization of unfit parents and birth control, those in charge of our animal world have long endorsed the soundness of these policies and carried them out on a vast scale.

In a sylvan setting on a government farm near Middlebury, Vt., is a bronze statue in honor of distinguished parenthood. It is not of a human being, but of a horse, Justin Morgan, the progenitor of the famous Morgan breed. I have not been able to learn of any comparable statue erected to man or woman in recognition of contributions to race improvement, biologically speaking. In determining number of offspring, those in charge of animal life produce as many as they can properly care for under current and prospective conditions. The Federal Government and the States freely distribute information on what the needs are likely to be for the different classes of animals.

Meanwhile the world's uncontrolled human population is making a net gain of nearly 100,000 persons a day, of which the United States contributes about 3,700—enough to establish a small town every day. The question naturally arises whether it is wise to outlaw birth-control knowledge and continue to increase human population in a nation and world where competition for existence is already fierce. Or are not the live-stock folks acting more rationally in controlling both numbers and quality?

Eugenics societies and some religious groups merit commendation for their zeal in genealogical studies. But even these progressive organizations have been outmarched by groups engaged in the improvement of the lower animals. Live-stock breeding associations have set up official records of performance for measuring attainments, such as speed in horses, milk yields in cattle and egg production of fowls. The worth of an animal as a parent is judged largely by the quality of all its offspring—not just a few of the best. The record work is intricate,

but it gives the desired results. I asked a nationally known genealogist why, if all this was worth while for the lower animals, it wouldn't be much more so for people. He agreed that it would, but added, "We just don't do it."

Merely as one example of how comparable human records would be useful, consider the advantage of knowing positively the racial history of a prospective mate. Such a system would tend to prevent the heartache of Caucasian mothers who have married presumably white suitors, but have borne dark-skinned babies with other unmistakable negroid characteristics.

Sound judgment, of course, denies any direct transplanting of method, but the animal world provides answers to several human problems. Birth control is sound in principle. The best measure of parents is not so much their ancestors but the kind of children they have. Our genealogies can be made to indicate the prospective physical traits, talents and temperament of our children, when the records are complete in such matters as stature, longevity, occupation, avocations, and the like.

Better Health

The same basic knowledge regarding anatomy, medicine and means of preventing disease serves man and animals alike. But there are striking differences in the manner some of this knowledge is applied. A tuberculous person may board a train in New York City and travel across the continent in close association with fellow passengers. He may chat with them, play cards with them and eat with them. He would resent interference with his independence. But if that person attempted to ship a cow in a stock car, he would not find it so easy. He would have to show that the cow had passed an official tuberculin test or was from a recognized accredited area. Under permit, diseased cattle may be shipped for slaughter, but in that case Uncle Sam puts a placard on the car, ordering its cleaning and disinfecting when unloaded, and there is an inspector on hand to supervise the job. When live stock go traveling, especially across state lines, Uncle Sam is on the job with John Law to back him up.

Most major live-stock maladies and scores of lesser ones have yielded to veterinary attack. Briefly, the United States is now widely regarded as the safest country in the world for the raising of live stock. The procedure for eradicating certain diseases is noteworthy. When an official veterinarian goes on to a man's farm or ranch to test cattle for tuberculosis, he does not present a bill for the work. On the contrary, he arranges to pay a fair indemnity for any cattle found to be diseased. The owner also gets whatever salvage the diseased cattle will bring. In other words the owner gets paid for getting rid of such animals, and the testing is free.

But the procedure is not so topsy-turvy from a medical standpoint as this description may sound. The officials who direct this work are interested primarily in serious infectious diseases. These are the ones that spread and spread, causing economic loss and often endangering human lives as well. So the officials have concentrated on the most dangerous diseases and have left the remaining field largely in the hands of private practitioners. The government also maintains rigid quarantines against infection from abroad, and these apply to many animal products as well as to the animals themselves.

This outline of official veterinary service is offered in answer to the question, "Is state or socialized medicine sound and proper?" There has been much discussion of this question, but the correct answer is clear. Leaders in the medical profession, with becoming grace, have often paid tribute to the

remarkable success of "state medicine" for animals and the resulting public benefits. By proper adaptation, what is good for a lower animal would logically be good for a higher one. In fact, man already has some state medicine indirectly because improved live-stock health has reduced several human ills and the death rate associated with such ills. In the light of this experience, state or socialized medicine is sound and proper when limited to those diseases that endanger society.

Law and Order

In seeking clews from the live-stock world on best methods of curbing crime and enforcing laws, we find many striking analogies. For scores of years stockowners have maintained brands and other marks of identification. On this basis, the practice of human finger-printing is eminently sound and deserves much wider application among our citizens. Typical animal "criminals" are the sheep-killing dog, unruly bull and predatory wild animals, and let us not overlook also the ordinary rat. Live-stock officials and owners tolerate no leniency in dealing with such enemies. They likewise practice scientific methods of prevention and control. They breed cattle without horns. And the domestic hog, though descended from the fierce wild boar, has been bred into a relatively peaceful animal. The principle of disarming the criminal element is thus obviously sound.

The practice of offering bounties for the capture of wild predators has given way gradually to the better system of an aggressive hunt. Bounties and rewards thus seem to merit but a minor place in law enforcement. The skilled stockman limits the kind and amount of stimulating feeds he gives to animals of nervous temperament. He eradicates or keeps his stock away from toxic plants. These procedures point to the soundness of supervision over too liberal use of drugs and narcotics by the human family.

The type of federal and state laws that apply to live-stock affairs is also noteworthy. These laws deal essentially with objectives to be reached, together with specified penalties for violation. They likewise designate responsibility for their enforcement and outline the means. Yet they provide, also, discretion and latitude of administration by empowering designated officials to make rules and regulations.

This type of law has been eminently successful. As need arises, new provisions are added to meet new developments and old provisions are dropped as they become obsolete. All changes, of course, are well within the original basic authority, and interested persons receive proper notice. Those subject to the laws always have redress in the courts if they wish to challenge a new order or ruling. In brief the live-stock laws are kept up to date, a condition which, in itself, commands respect. A further basis for respect is their impersonal enforcement. One federal law, for instance, provides that animals brought here from specified foreign countries must undergo veterinary observation in quarantine. This law applied to Kedron, the war charger of General Pershing, on returning to the United States at the close of the world war. Acclaimed by the nation, the general led his victorious legions in colorful parade from the Capitol to the White House—but he rode another horse. Kedron was in veterinary quarantine.

The penalties provided by the laws which govern this inner live-stock democracy are high enough to command respect and compliance. A reckless driver or speeder on a city street, endangering human life, feels aggrieved if fined \$5, \$10 or \$25. I recently spent two days in court in Washington, D. C., as witness for a friend whom I had seen run down by a truck with bad brakes. Counsel for the defense brought forward an array of excuses, and the truck driver finally received a fine of \$25. But if, instead of

striking a human being with a truck, this man had failed to unload hogs, en route to market, for feed, water and rest, he likely would have paid a fine of $100, the minimum penalty for mistreating live stock under the 28-hour law. He would have faced a similar fine for driving ticky or tuberculous cattle across a state line.

Should an offender feel gifted in inducing friends at court to fix traffic tickets or dismiss charges against him, he will wisely omit such tactics in live-stock jurisprudence. Especially is he cautioned not to try his persuasive powers, accompanied with a gift, on a federal veterinarian engaged in meat inspection. To give or offer money or anything of value to an inspector with intent to influence him in the discharge of his duty is a felony. The least penalty, on conviction, is a fine of $5,000 and a year's imprisonment.

Practical Labor Applications

To extend experience with animals to the intricate problems of labor relationships may seem fantastic. But let us consider several ranging from immigration to child labor. The animal population, like the human, originated largely in other countries. Choice breeding animals are welcome from abroad without limit. In fact, the government itself has sought out high-quality animals from remote parts of the world. But unhealthy or otherwise unfit animals find no such welcome. Thus animal immigration is highly selective.

In the field of racial problems, the separation of different classes and breeds of animals has long been a live-stock custom. Each has its separate quarters on farms, even though several kinds may run together on occasions. Different biological species, in brief, do not mix well from an economic or management standpoint. The inference is: In general keep races of workers separate. They get along better with their own kind.

Among the animal "workers," compensation is in terms of feed, housing and care. The better bred and more productive receive preferential treatment in these respects. The reasons are economic, not sentimental. The animals that earn more for their owner receive more from him. Applied to human affairs, the deduction is that efficiency and volume of production are the proper bases for wages. And since even an inferior specimen, that is good enough to keep, merits at least a maintenance ration, and commonly receives more, the principle of minimum wage is sound. In the production of most animal products the curve of efficiency roughly approaches that of an arch, rising to its greatest height in the prime of life and then declining. On the basis of this analogy, the correct principle of wages for human physical work is advancement from the period of youthful effort to that of greatest output, followed by some curtailment in the worker's declining years. The human custom of retaining aged persons in positions that make too heavy drains on their constitutions is contrary to sound biological practice. The principle of adequate vacations, with pay, is supported by analogies in the animal world, ample rest periods being essential for the best productive effort.

There is practically no unemployment in our animal economy, owing to foresight in regulating the number of workers. Once in three years the Bureau of Animal Industry surveys the horse and mule situation and points out the prospective needs several years hence. The data include number, ages and quality of breeding stock and of young animals approaching working age. This service has been useful in adjusting the supply to the probable requirements.

There is a virtual taboo in live-stock circles on the use of immature animals for steady work. That would be injurious to the animals and unsound from a practical standpoint, regardless of the

humanitarian side. On this basis child labor is unsound, and measures for preventing such labor have ample support from the live-stock world.

Adequate and sanitary housing has a close parallel in both human and live-stock fields. Merely on the grounds of economic productiveness, good housing is sound. Witness the many farms on which the barns have surpassed the human dwellings at least until returns from farm operations were sufficient to finance better homes. There is abundant live-stock experience to support slum-clearance programs.

Basis for Skilled Statesmanship

Experience from the animal world, of course, has scores of other applications to human affairs. Veterinary and other scientific gatherings suggest means of improving legislative procedures. Before such technical groups there is an orderly presentation of evidence, but little debate. Action on the evidence is commonly unanimous or nearly so. The facts speak for themselves. Oratory, whether laudatory or acrimonious, has slight influence on the discerning scientific mind, and is regarded largely as an entertainment feature. Hence in legislative debates on questions of public welfare—which parallel those of animal welfare—extensive argument indicates an absence of sufficient evidence. Decision had better be deferred until more facts are at hand. The same is true of close votes involving only a slight majority. New legislation which lacks support by a large majority may be looked at askance, possibly in the light of a temporary expedient rather than as sound statesmanship.

Although perhaps a coincidence, it is noteworthy that many of this nation's best chief executives and congressional leaders have had a background of farm experience, giving them an intimate understanding of natural laws. Quite conceivably this rural knowledge may have added wisdom to their judgment in the administration of public affairs.

Tradition, of course, is strong, having too powerful a grasp on thought and conduct to permit early departure from present habits.

Yet when one must plan a new course or make a difficult decision, he may wisely scan the efficient conduct of the animal world for sound precedent and safe guidance. Of course, there is the stereotyped challenge, "But you can't treat human beings like animals." True—but why not treat them at least as well?

BOOKS ON SCIENCE FOR LAYMEN

WEATHER IN WORDS AND PICTURES[1]

THIS is a republication by a new firm, but with none of the many needed changes of text. It is such a beautiful piece of book-making, however, that it deserves to be adequately revised, with the replacement of half its 59 illustrations by others more closely and obviously related to the subject-matter. Its errors are far too numerous to discuss in detail, so only a few of the more important will be cited.

Long ago some animist explained atmospheric convection by asserting that warm air rises (presumably voluntarily as a cat climbs a tree) and cold air comes in to take its place and thereby prevents the formation, or maintenance, at least, of a vacuum—voluntarily, presumably, and out of the kindness of its heart! Ever since that unhappy day nearly all writers, including many who, like Mr. Pickwell, certainly know better, persist in perpetuating this absurd error, instead of explaining convection correctly, intelligibly and in even simpler terms.

On page 19 it is erroneously stated that the blue of the sky is caused by dust particles. And on the next page we find the absurd statement (not original with Mr. Pickwell, however) that if there were no dust particles the sky would be black. The paragraph that contains this last error contains also several others.

The exceedingly misleading idea that the air holds water (as does a sponge, perhaps) is repeated over and over, whereas the air is inconsequential in this particular. This error, too, is persistently repeated by many other writers. Some even state the matter correctly in one sentence and wrong in the next.

Mr. Pickwell says (page 40), as do many others, that the air is cooled mainly by being pushed up into colder regions aloft, not by the loss of heat through the work of expansion against the surrounding pressure.

The explanation of "black" lightning, page 96, a purely photographic effect, is quite the worst I have seen. And there are many other slips. The text needs a thorough revision.

On page 145 the oft-quoted statement, "Everybody complains about the weather, but nobody does anything about it," is, as usual, credited to Mark Twain, and not, as it should be, to Charles Dudley Warner.

But for all that, the two-page picture of a tornado cloud is worth the price of the book.

W. J. H.

[1] "Weather." By Gayle Pickwell. Illustrated. ix + 170 pp. (quarto). $3.00. McGraw-Hill Book Company.

PRACTICAL SCIENCE IN THE HOME[1]

ALTHOUGH this book is designed as a college text for courses in home economics, it has in it so much of interest and importance for both the inside and the outside of the house that the head of every household should find it a valuable handbook. In our modern mechanized life, whether we live in the city or in the country, we are surrounded by the products of science which often require expert attention. To be able to service them is a great saving in time and money; to understand how to do it gives one the satisfaction of being the master. The numerous problems in this book would be to many persons much more entertaining than any cross-word puzzle.

There are in this book five general divisions—"Mechanics," "Heat," "Electricity," "Sound" and "Light." After explaining in each of them in elementary terms the basic principles of the subject, innumerable applications in the home are taken up from the practical point of view. For example, under "Mechanics" there are illustrations from such familiar

[1] *Household Physics*. By Madalyn Avery. xv + 489 pp. and 378 cuts. $3.50. The Macmillan Company.

things as the pump-handle, nut cracker, wheelbarrow, human arm, steering wheel, clothes wringer, gears, jack, window sash, sewing machine, including lock stitch and tension, hydraulic brake, barometer, pressure gauge, suction pump, force pump, vacuum cleaner, gas regulator, gas meter, gas burner, water supply, water meter, bathroom plumbing, including faucets and valves, sewage pipe, flush valve, flush tank and septic tank. The reader will be surprised at the small number of simple principles on which the mechanical operation of all these things depends.

Under "Heat," to mention a few things, we find the thermometer, thermostat, oven temperature regulator, steam cooking utensil, pressure cooker, insulation, vacuum bottle, refrigerator, stove, furnace, hot-water boiler, air-conditioning unit and weather. Again the basic principles are few and the practical application to affairs of every-day life in the home are many.

In the section on "Electricity" there are found not only the almost numberless appliances using motors, but also heating devices of all kinds from curlers to hot-water heaters and ranges; there are also electric lamps, electric plating and electric cleaning of silver. Then follow matters of electric wiring, meters, fuses, transformers, batteries, household generating units and lightning.

Under "Sound" we find the human ear, noise, musical instrument, microphone, telephone receiver, loud speaker and related things. Under "Light" not only the human eye and illumination, but also optical instruments of various kinds and even x-rays and their uses. This partial list of subjects treated gives a general idea of the scope of the book. It is a pleasure to express the opinion that the discussions in it are clear and scientifically sound and that the illustrations are excellent. Probably even more important than the practical usefulness of the book is the scientific attitude toward the affairs of every-day life that it will stimulate. F. R. M.

SOME FACTS OF SCIENCE OVERSIMPLIFIED[1]

In an attempt to give a reasonably clear notion of the nature of the atom, a scientific writer sometimes likens its structures to that of a miniature solar system. This analogy reveals, to the lay mind, at least, what is akin to a sense impression of this small unit of matter. So every careful investigator tries to use some effective device by which to present his knowledge to others.

It would seem that under so good a popular title as "The Magic Wand of Science" an author should be able to fire the imagination of his reader and thus the better to acquaint him with many significant facts. Such a result could be accomplished by careful selection of material and by a sufficiently complete setting forth of fundamental data to enable the reader both to comprehend the significance of the things discussed and especially to glimpse something of the scientific processes by which these things are created and utilized. In these matters the author of the book in question seems to have failed in great measure. The facts presented are generally known by all who may read the book; the presentation is so commonplace that the reader gets little more than the names of the items presented together with a rather broad statement of their significance. The account is much like a newspaper recitation of certain inventions and discoveries that are already known to the average high-school boy and to most men on the street. It hardly needs a book with an apt title to reveal that the things enumerated exist and that the names of certain men are connected with them.

J. E. Thornton

Brookings Institution,
Washington, D. C.

NOT MUCH ABOUT PETROLEUM[1]

The table of contents of this little book

[1] *The Magic Wand of Science.* By Eugene W. Nelson. Illustrated. 212 pages. $2.00. E. P. Dutton and Company.

[1] *About Petroleum.* By J. G. Crowther. Illustrated. xiv + 181 pp., 14 plates. $2.25. Oxford University Press.

lists chapter topics covering essentially all phases of the petroleum industry. It is obvious that few if any individuals could claim to be sufficiently well informed to write authoritatively or to examine critically more than a few of them. The present reviewer feels that his competency for a critical examination of the subjects included is restricted to those chapters concerned with the origin, production, exploration and drilling for oil. His reactions to those portions are so unfavorable that, regardless of the merit of the other sections, it is felt that the book is not suitable for use for the avowed purpose of providing a "simple introduction to 'The Science of Petroleum.'"

Numerous instances of misplaced emphasis and of statements not in harmony with the theories generally accepted in the United States regarding the origin and accumulation of petroleum occur in the first and other chapters.

It is difficult to select specific inaccuracies without implying that the ones mentioned are the most important; they can not all be included, for the list would be too long. It is to be regretted, moreover, that the statistics presented in the book in general are not for any period more recent than 1936, whereas reasonably accurate statistics for the petroleum industry for 1937 have been available since February of 1938. It is unfortunate that portions of a book of this scope which might have provided a useful general survey of the various phases of an important industry contain so many statements which seem to be at variance with theories generally accepted in this country.

GAIL F. MOULTON

BIG FLEAS HAVE LITTLE FLEAS[1]

SHOULD scientists try to give to the layman the results of investigations in their own fields? This is a problem which has caused much discussion and for which there can be no one answer which will apply to all cases. Dr. Robert Hegner has given his personal answer to this question in the book "Big Fleas have Little Fleas." Not only has he written a book which can be understood by any layman who is willing to read, but he uses clever line drawings and catchy rhymes to drive home his points. The study of the Protozoa is a very new field and the author has actually lived through many of the phases about which he tells. This makes it possible for him not only to give information about the subject, but what is just as important, to tell how such information has been obtained.

As the title indicates, the book has as its main subject the story of parasitic Protozoa and stresses particularly those which are of importance to man, although the free-living forms are by no means neglected. Sarcodina, Mastigophora and Infusoria are introduced so that their parasitic members as well as those of the Sporozoa can be passed in review. Of the parasites, a few of those which inhabit lower forms of animals are discussed so that the problems of commensalism, symbiosis and parasiticism can be made clear. Most of the book deals with important human types, such as the organisms causing amoebic dysentery, malaria and African sleeping sickness.

Every human being is directly or indirectly affected by the Protozoa, but very few realize how important their place in nature is. Those who yearn for the good old days have no conception of the changes which our knowledge of these simple organisms has produced on the human race. Reading this book will open their eyes to the problems involved and help them understand the ways in which this knowledge has been obtained, and incidentally show them the tremendous number of problems which still remains to be solved.

D. B. YOUNG

[1] *Who's Who among the Protozoa.* By Robert Hegner. Illustrated. 285 pp. $3.00. Williams and Wilkins Company.

THE PROGRESS OF SCIENCE

MEETING OF THE AUSTRALIAN AND NEW ZEALAND ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE arrival in Canberra (pronounced Canbrough!), the capital of the commonwealth of Australia, at five o'clock on the evening of January tenth was the welcome termination of a hot, dusty, steaming, 500-mile drive north from Melbourne through a smoke-drenched country which made it impossible to see the surrounding hills and which choked one's throat and made one's eyes red and uncomfortable. The temperature as we went through Albury—about half way to Canberra—was 107°, and every one was looking limp and miserable. However, after a cool shower (the cold water was actually warmish!) and a change, the world seemed cooler and less grimy.

Many of the delegates had arrived previously at the Hotel Canberra, and the first evening was spent meeting other overseas delegates and the officers of the Australian and New Zealand Association for the Advancement of Science. The official guests from England were Sir John Fleet, Sir John Russell, Professor F. T. Brooks, Professor N. V. Sidgwick and Mr. H. G. Wells. Professor R. H. Carr, of Purdue University, and I represented the American Association for the Advancement of Science. We all received most cordial and generous hospitality.

The meeting proper began on Wednesday, the eleventh of January. The American delegates were invited to attend the general council meeting, which was managed in a very business-like manner. At noon the over-seas delegates were entertained at luncheon by the president, Professor Ernest Scott and Mrs. Scott; at 2:30 P.M. the Minister of the Interior, Mr. Mac Ewan, and Mrs. Mac Ewan gave a reception for the over-seas delegates and at four o'clock the Ministers of State gave a garden party at Parliament House.

After dinner that evening there was a formal meeting, at which the presidential address was delivered, Professor Scott's topic being "The History of Australian Science." His subject was particularly timely, for the Canberra meeting closed fifty years of accomplishment of the Australian and New Zealand Association. This gala opening was attended by Their Excellencies, the Governor-General of Australia Lord Gowrie and Lady Gowrie, who entertained the over-seas delegates at luncheon on Thursday at Yarralumla, Government House. Government House is a charming place, set in beautiful gardens. Work has already been started on improving Yarralumla for the advent of the Duke and Duchess of Kent; the Duke of Kent is to be the next Governor-General of Australia.

Yarralumla, as it was in January, is the sort of place which belongs to Canberra, that strange fascinating capital which is being built from outside in and which has room to spread in every direction. Selected after years of discussion, and, if history be true, heated argument as a compromise point not too much resented by either New South Wales (where Sydney is located) or Victoria (where Melbourne is situated), Canberra is really beautifully nestled among low hills presenting vistas toward distant mountains. Lying in a valley about 1,800 feet above sea-level, its summer weather is ordinarily quite comfortably cool, but this year it was *unusual* (the kind they have in Southern California when the weather is *bad*).

Construction of Canberra was begun after an international competition for a design for it was held, the first prize having been awarded to Walter Burley Griffin, of Chicago, who eventually went to Canberra to proceed with the

HOUSE OF PARLIAMENT

development of the plan. In his description of Canberra Mr. C. S. Daley, of the Department of the Interior, says: "The plan as originally drawn is regarded as being of marked distinction and originality. The author made skilful use of the excellent features presented by the site of effective planning. These consist of the scenic background of the Australian Alps; local mounts affording terminals to vistas and sites for future monuments; hills and spurs providing appropriate sites for public buildings and also terminals to main thoroughfares."

Canberra has lovely, wide streets, beautiful parkways, rich public gardens and a comfortable feeling of plenty of room. And in the midst of all this planned beauty, of all this striving for perfection and spaciousness, what do we find? We find three slum areas which should not exist and which are foci of delinquency, and that in a place which has been planned from the beginning!

On Thursday most of the presidential addresses were delivered and the scientific programs were under way. The Section on Anthropology was perhaps of greatest interest, one of the most fascinating illustrated lectures presented before it being that of Mr. E. W. P. Chinnery, one of the government anthropologists, who is director of District Services and Native Affairs of the Territory of New Guinea. He showed pictures of and described the exploration of an area in 1933 of 10,000 square miles, which is bordered on the north by the Bismarck range and on the south by a newly discovered range, three peaks of which are 13,000 feet in height. In 1934 Mr. Jack Hyde, sent by Sir Hubert Murray, pushed 100 miles northwest of the farthest point reached in 1933 and found a type of people similar to those encountered in the 1933 expedition.

This area contains some 200,000 people, who had never heard of the British Government or of any other government for that matter. Living at an altitude of 5,000 feet, there is apparently no link between them and the coast.

There are found in this region mortars

and pestles, stone birds and curious clay whistles. The clay whistles, found at Chimbu, are dried but not baked. The people play interesting games with humming tops, and they have very elaborate dances. Frequently one hears them yodling, but it is an original kind of yodling, not like that of the Swiss.

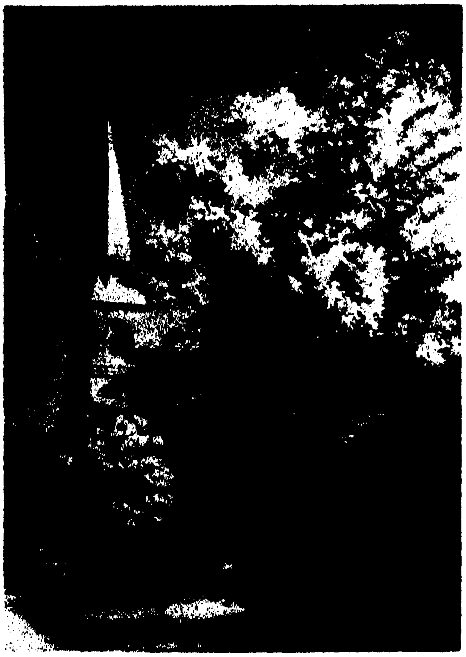
Miss Olive Pink presented a paper entitled "Bone-Pointing by Whites and its Past and Future Contribution to the Extermination of the Full-Bloods—the Aborigines of Australia," which gave a critical point of view of the treatment of the aborigine. Several illustrated papers on the art of the aborigine were presented, among the contributors being C. P. Mountford, R. H. Goddard and W. J. Enright. Australia is having a hard time keeping its anthropological treasures intact, for travelers here, as in all parts of the world, apparently are driven by some strange compulsion to carve their initials over these priceless records.

The Section on Medical Science and National Health had for its leading topic "National Fitness," which was the subject of the presidential address by Dr. E. Sydney Morris. Among the interesting papers in this section were ones on "Heart Size in Relation to Physical Exercise" and on "Physical Education as a Means to National Health," by Dr. Fritz Duras.

The Medical Section had joint discussions with Chemistry, Physiology and Pharmaceutical Science on the "Relationship between Chemical Constitution and Biological Activity," and another with Agriculture, Veterinary Science, Botany and Physiology on "Virus Diseases," and finally another with Physiology on "Animal Pigments."

In the Section of Education the presidential address by Mr. J. R. Darling, entitled "Growing up," was stimulating and thought provoking. Mr. Darling, head master of Geelong Grammar School, in Victoria, said experts could learn a lot from the ordinary man, and that it was a common sin of experts—and none were greater sinners than head masters—to

AUSTRALIAN INSTITUTE OF ANATOMY



THE OLD CHURCH OF ST. JOHN

COURT YARD OF THE HOUSE OF PARLIAMENT
WHERE THE SUPPER WAS SERVED AT PRESIDENT SCOTT'S RECEPTION.

brush aside the criticisms of their victims, concluding with the remark that the supreme object of education should be to help men and women toward constant, imperturbable yet active serenity of soul.

The Section on Agriculture and Forestry was faced with a real problem in the terrific bush fires (forest fires) which were raging in Australia during the first half of the associations' meetings. Australia has been reckless and ruthless in her destruction of trees and in her lack of conservation, and she has paid dearly for insufficient fire breaks and for permitting an accumulation of dried tinder-like material in her great forests.

Mr. Ambrose Pratt, an authority on the koala bear and the lyre bird, discussed the damage done to the koala bear in the recent fires. The sanctuary at Healesville, in Victoria, was threatened, and the little bears living in the sanctuary were billetted out in private families during the crises. Ordinarily it is an offence, punishable by a very heavy fine, to have one of these little bears kept in a private home. The koala is undoubtedly Australia's greatest native attraction, and because of its defencelessness and because of its very specialized diet, Australia had enacted legislation, designed to protect this delightful little creature from harm.

The great tragedy in all these science congresses is that very frequently papers that one wishes to hear in different sections all come at the same time. The writer was torn with indecision one day when five important papers in five sections all came at the same hour. Of course, we all went to hear H. G. Wells paint a gloomy picture of how the world is going to blazes, of how inadequate education is and how it can be saved through the rapid and zealous expansion and organization of the English-speaking community. Mr. Wells' two addresses caused a great deal of discussion and, as usual, he not only managed to get people to thinking, but got them articulate about it.

Sir George Simpson gave an excellent illustrated public address on the Ice Age.

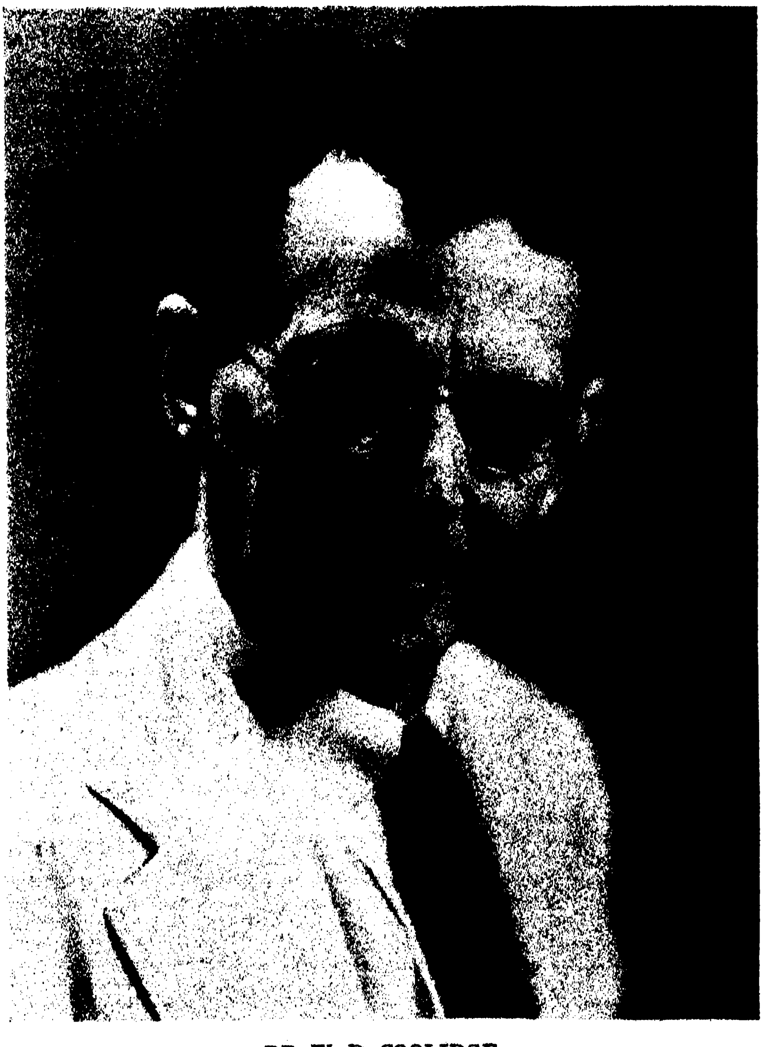
This lecture came after a 50° drop in temperature, and after it a number of scientists went to see "Too Hot to Handle," which was playing in the town.

Social functions and delightful excursions added greatly to the pleasures of the Canberra meeting. The reception of the president was held in Parliament House, giving every one a chance to roam through the lovely building and to see the fine collection of historical exhibits. Supper was served in the beautiful and brilliantly lighted courtyard. The other very large function was a great garden party at Government House on a day when bush fires were raging and the air was hot and full of smoke.

ANITA M. MUHL, M.D.

AWARD OF THE FARADAY MEDAL TO DR. W. D. COOLIDGE

IN 1922 the Institution of Electrical Engineers, in London, established the Faraday Medal to be bestowed annually upon a scientist for some notable scientific or industrial achievement in electrical engineering, without restrictions as



DR. W. D. COOLIDGE

to nationality, country or membership in scientific societies.

It is appropriate that such a medal should be named after Faraday, who, by establishing the relationship between electric currents and magnetism about a hundred years ago, laid the foundations for all the remarkable and extraordinarily useful achievements in electrical engineering that have been the wonder of the world. The first Faraday medallist was Sir Oliver Heaviside, and the latest is Dr. William David Coolidge, director of the Research Laboratory of the General Electric Company. Among the others who have received the Faraday Medal are such great British scientists as Sir J. J. Thomson, Lord Rutherford, Sir Oliver Lodge, Sir William Bragg and Sir John Snell. Previous American recipients of the honor have been Dr. J. A. Fleming and Dr. Frank B. Jewett.

Dr. Coolidge is by no means a stranger to honors, having received the Rumford Medal of the Royal Society of London in 1914, the Howard N. Potts Medal of the Franklin Institute in 1926, the Louis Edward Levy Gold Medal in 1926, the Gold Medal of the American College of Radiology in 1927, the Hughes Medal of the Royal Society of London in 1927, the Edison Medal in 1927, the Washington Medal of the Western Society of Engineers in 1932 and the John Scott Award of the City of Philadelphia in 1937.

Medals and honors serve mostly in the eyes of the world as something on which to focus attention for a brief moment of hero worship. The things of abiding interest and consequence are the achievements they commemorate. It is much the same with scientists. Although they appreciate the approbation of their fellow men, especially of their scientific peers, their real satisfaction comes in exploring regions previously unknown and in discovering things that are permanent contributions to our understanding of the universe about us. Even if their discoveries give only intellectual pleasure they are satisfied; if they combine deep satisfactions to the mind with practical applications, as Dr. Coolidge's have done, they are delighted. In the presence of such satisfactions a medal is less important to the recipient than to those who read about it.

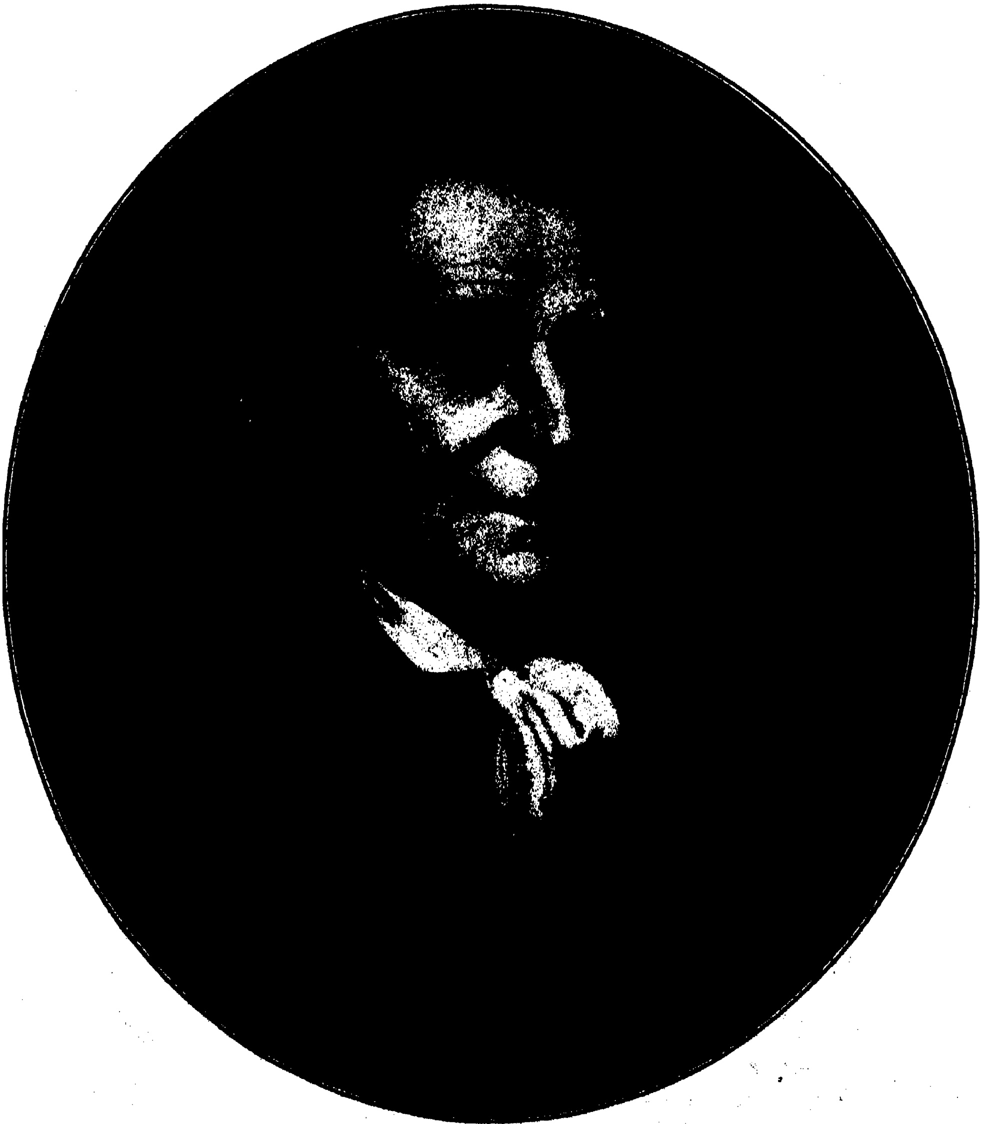
F. R. M.

WILLIAM BARTRAM'S BICENTENNIAL

THE steadily growing appreciation of William Bartram and his contributions to American literature and natural history is reflected in the celebrations this year of the two hundredth anniversary of his birth. On February 9 commemorative exercises were held at Rollins College, Winter Park, Fla., including addresses on several phases of Bartram's work and an exhibit of Bartram material.

At the same time a special exhibit of Bartramiana was opened at the Academy of Natural Sciences of Philadelphia; this includes books, drawings, letters, a diary and personal possessions of John and William Bartram, as well as portraits of themselves and some of their scientific friends and correspondents. Among the books is Alexander Wilson's own copy of Bartram's "Travels," recently presented by William Bacon Evans and Charles Evans. Another treasure in the academy's library is a copy of the tenth edition of Linnaeus's "Systema Naturae," presented by Dr. Thomas Hewston to William Bartram.

The John Bartram Association, of Philadelphia, has recently issued, under the authorship of Emily Read Cheston, a most informative little work on the father and the son, with an account of their old house and garden, still preserved on the banks of the Schuylkill in West Philadelphia. Last year the National Park Service issued a useful mimeographed sketch of William Bartram. In the *New*



Courtesy of the John Bartram Association

WILLIAM BARTRAM

FROM THE PORTRAIT BY CHARLES WILLSON PEALE NOW IN INDEPENDENCE HALL

Courtesy of the John Bartram Association

A DRAWING BY WILLIAM BARTRAM

THE "SCARLET CROWNED FINCH" IS AS YET UNIDENTIFIED. THE UPPER FLOWER, "ANISUM STALLATUM," IS A SPECIES OF *Illicium*. THE LOWER PLANT, "HOUSTONIA WITH A SMALL PURPLE FLOWER," IS CORRECTLY NAMED AS TO GENUS. (ORIGINAL IN BRITISH MUSEUM.)

York Times Book Review for February 5 appeared a timely tribute by N. Bryllion Fagin, author of "William Bartram, Interpreter of the American Landscape" (1933).

In further celebration of the Bartram bicentennial, a joint meeting of the Delaware Valley Ornithological Club and the Philadelphia Botanical Club is planned for April 20 at the Academy of Natural Sciences. This appears to be the real anniversary of William Bartram's birth, rather than the commonly cited February 9.[1]

[1] According to the records of the Darby Monthly Meeting of the Religious Society of Friends, he was born on "2 Mo. 9." In the Quaker calendar of that period, this means April 9, not February 9; and April 9 (old style) is the equivalent of April 20 (new style). For this information I am indebted to Dr. Edward E. Wildman, director of science education in the Philadelphia public schools.

Both as a literary treasure and as a contribution of the first rank to American natural history and ethnology of the eighteenth century, Bartram's "Travels" (Philadelphia, 1791) was accorded immediate recognition abroad, in the shape of new editions or translations in London (1792, 1794), Dublin (1793), Berlin (1793), Haarlem (1794–97) and Paris (1799, 1801). The inspiration that Coleridge, Wordsworth and other (chiefly English) writers drew from Bartram's work is well known. An excellent summary and discussion of these literary aspects is furnished by Fagin in the work already mentioned.

As a naturalist Bartram has not lacked his critics, from his own time down to the present day. The scoffers, however, are engaged in a steady retreat, and their voices are heard less and less. Wonder-

Courtesy of the John Bartram Association

ANOTHER DRAWING BY WILLIAM BARTRAM

THE SNAKE, IN THE ACT OF SWALLOWING A FROG, IS PARTLY CONCEALED BY PLANTS. IN THE CENTER ARE TWO SNAILS (*Polygyra*) AND, TO THE RIGHT, THE LARGE FRUIT OF WATER CHINQUAPIN (*Nelumbo lutea*). ABOVE ARE A DRAGON-FLY AND A HUMMINGBIRD. (ORIGINAL IN BRITISH MUSEUM.)

fully expressive of an extreme attitude on the part of the arm-chair critics is this anonymous gem written on the flyleaf of a copy of a London edition of the "Travels" in the library of the Academy of Natural Sciences, at the conclusion of a quotation from Bartram's remarks on alligators: "Bravo Yankee Doudle this out-Herods Herod."

Probably none of Bartram's observations has been subjected to such severe and long sustained criticism as this account of the bellowing and other activities of alligators on the St. John's River. After the lapse of a century and a half, however, nearly every detail of this account has been sufficiently verified by modern eye-witnesses of these activities. As time goes on, more and more of the debated topics in Bartram become settled —or at least elucidated—in his favor.

Many of his plants and some of his animals have never been fully identified; and their proper determination constitutes one of the major remaining problems for Bartram investigators. Another is the relocation of the points of special interest visited and described by John and William Bartram, and the retracing of their routes in general through the southeastern states. Considerable progress on both lines of investigation has been made recently in eastern Georgia, and further reconnaissance along the Bartram routes throughout the Southeast is planned for the near future. Also in prospect is the publication of a lengthy and highly significant manuscript of William Bartram's which throws much new light on his published "Travels"; likewise the publication of John Bartram's diary of his 1765–66 trip (hitherto largely unpublished). The entire undertaking is being sponsored by the John Bartram Association.

It is most fortunate for students of our fauna and flora that a naturalist of William Bartram's versatility and accuracy appeared on the American scene, to become our most commanding figure in zoology, at least, during the long decades between Mark Catesby and Alexander Wilson. Certain it is that he has left us an indelible and altogether priceless record of American natural history in the eighteenth century.

FRANCIS HARPER

JAMES PLAYFAIR McMURRICH

SCIENCE in North America lost one of its most brilliant devotees recently through the sudden death of Professor James Playfair McMurrich from coronary thrombosis on February 9, 1939. Professor McMurrich possessed the qualities of true greatness and was endowed with such vigor of mind and spirit that he rose to distinguished achievement during his long and active life.

His rare ability was never used for personal aggrandizement, but only for the advancement of the science to which he was passionately devoted. Unselfishly he put forth his efforts to furthering the ultimate good of the universities, learned societies and commissions of which he was a member and leader. As a natural consequence many honors were heaped upon him, all of which he bore with becoming modesty.

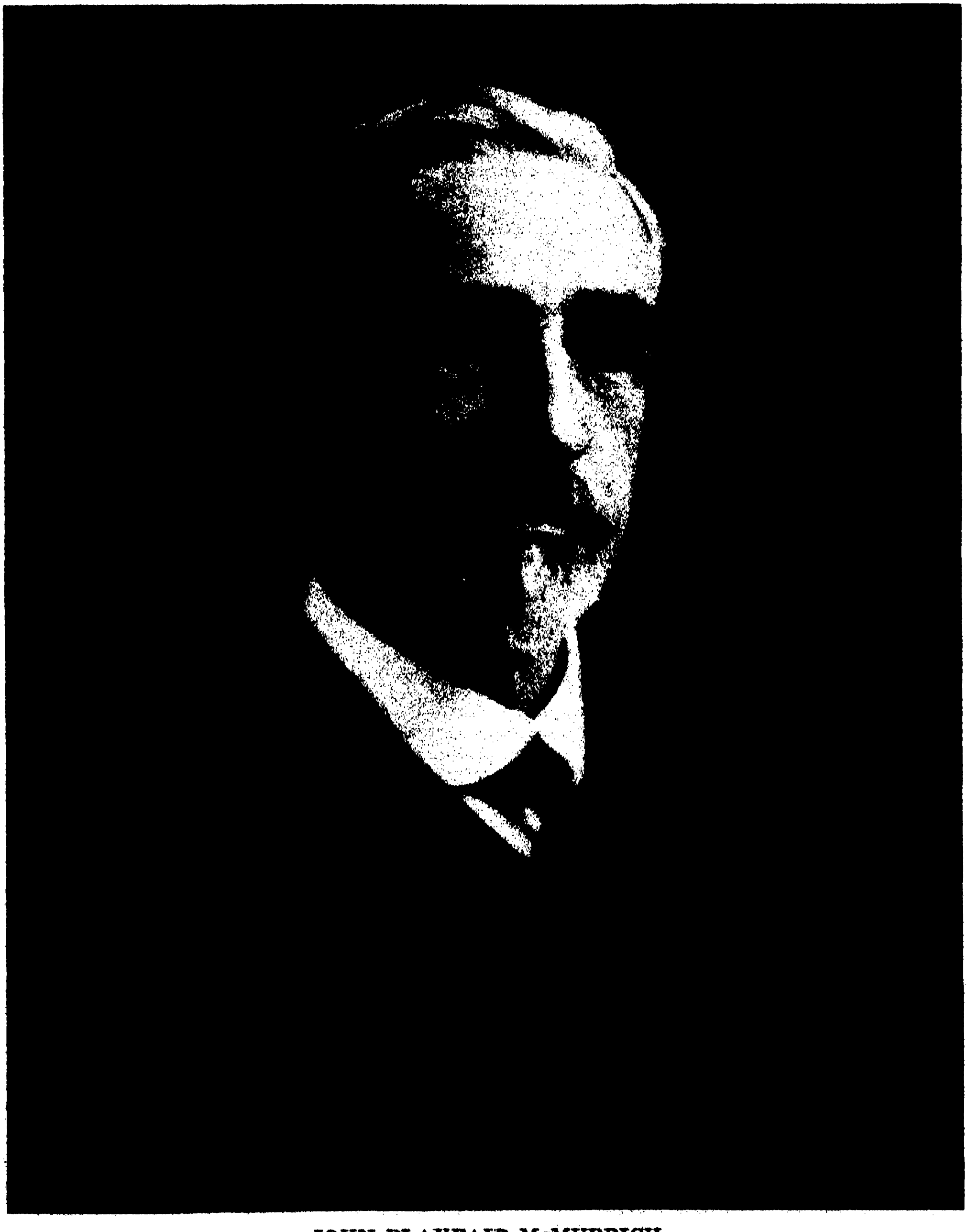
James Playfair McMurrich was born at Toronto, Canada, October 16, 1859, the youngest of eight children, his parents being the Honorable John McMurrich, M.L.C., and Janet Dickson McMurrich. His early education was at Upper Canada College. Proceeding to the University of Toronto, he graduated with the degree B.A. in 1879, some months previous to his twentieth birthday. The M.A. followed in 1881, and then at Johns Hopkins University he received the Ph.D. degree in 1885. Honorary degrees of LL.D. were later conferred upon him by the University of Michigan (1912), University of Cincinnati (1923) and the University of Toronto (1931).

The rise of Professor McMurrich in his profession was rapid, and his academic positions give evidence of his versatility and wide knowledge. The earlier posts held were: professor of biology, Ontario Agricultural College, 1882–84; instructor in mammalian anatomy, Johns Hopkins University, 1884–86; professor of biology, Haverford College, 1886–89; docent and assistant professor of animal morphology, Clark University, 1889–92; professor of biology, University of Cincinnati, 1892–94.

During these early years his fame was already widespread and brought him an invitation to become a professor of anatomy, which he refused. When, however, a second university repeated this invitation, a brilliant tribute to his powers, he felt that the call to this new sphere should be heeded, and he became professor of anatomy in the University of Michigan, 1894–1907. From there he returned to his alma mater as professor of anatomy, University of Toronto, 1907–30, which post he occupied with distinction until his retirement at age seventy as professor emeritus.

In Toronto he took a great interest in the development of graduate work and research. He was instrumental in the founding of the School of Graduate Studies, which grew rapidly under his leadership as the first dean, 1920–30, and he was active and influential in many scientific organizations.

Tall and thin in build, with a very finely formed face of highly intellectual type, Professor McMurrich gave, at first sight, an impression of physical frailty, which was deceptive, for it was compensated for by an intensely vital nervous energy. In spite of a physical discomfort from which he suffered during the greater part of his lifetime, he was capable of carrying heavy burdens, though his driv-



JOHN PLAYFAIR McMURRICH

ing zeal continually made excessive demands upon his bodily strength. He produced a total of 107 publications, including his books, "Invertebrate Morphology," "The Development of the Human Body" (seven editions), Morris' "Human Anatomy" (fourth edition), "Sobotta-McMurrich Atlas of Human Anatomy" and the section on the muscular and vascular systems in Piersol's "Human Anatomy." Another of his notable books was "Leonardo da Vinci—the Anatomist."

His truly remarkable memory, coupled with the deepest interest, made it possible for him to accumulate and retain an astounding amount of knowledge on many subjects which he was able to recall at will and use with keen insight and discrimination. As was often revealed in his conversation, his profound scholarship extended to many subjects entirely beyond his wide professional field.

As an internationally famous zoologist Professor McMurrich was chosen as the authority to whom were sent all specimens of Actinozoa collected by the Siboga deep sea expedition. Research work of some years' duration was devoted to the study and classification of these specimens. As chairman of the Biological Board of Canada and a member of the North American Committee on Fisheries Investigation for many years he traveled extensively, and in 1923 he represented Canada at the Pan-Pacific Congress in Sydney, Australia. He took keen scientific interest in fisheries, and an extensive series of papers on the salmon of the Pacific Coast climaxed his active research in this line.

For nearly thirty of his later years a major interest was the history of anatomy, which he continued to study after his retirement from the university. Many ancient books were read fluently in Greek and Latin, for Professor McMurrich desired to form his own opinions for incorporation in a reference book on the history of anatomy which he was writing and which was well advanced at the time of his death. When the Arabian period blocked his access to original sources he was undaunted, and at the age of sixty-two he learned Arabic so that he might gather his information at first hand.

He was no recluse, but occupied a high place in the social life of the community and in the esteem of his fellow men. He greatly enjoyed his various clubs and for many years was interested in the work of his church. He was very fond of travel and was an enthusiastic golfer. His life was well-rounded out and gloriously complete. He was a distinguished gentleman, scholar and scientist, admired and loved alike by colleagues, students and a host of friends.

JAMES CRAWFORD WATT, M.D.

HARD COPPER—CUPALOY

A TRADITION has come down through the ages that the ancient Egyptians knew some secret process of making copper as hard as steel. Indeed, it has often been assumed that knowledge of how to make copper tools that would cut stone made possible the construction of the pyramids. In vain the lost formula for making "hardened copper" has been sought.

Alloys of copper, tin and zinc, called bronzes, are much harder than pure copper and have been known from ancient times. But they are not "hardened" copper and, what is more important, they lack important properties of copper, such as high conductivities for heat and electricity. Just as scientists were reaching the conclusion that hard copper is a myth, the metallurgists of the Research Laboratories of the Westinghouse Electric and Manufacturing Company produced a copper alloy that has not only the hardness ascribed to the hard copper of the Egyptians but also other very desirable properties. There is not, however, the slightest probability that the ancients had this recently produced alloy.

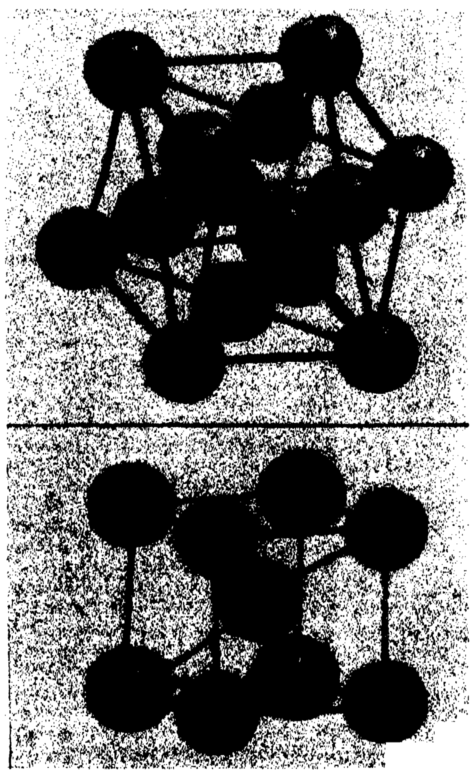
The new hard copper, known as Cupa-

CRYSTALLINE METAL
PLASTICALLY DEFORMED, IN WHICH THE SLIP PLANES APPEAR AS STRAIGHT LINES. (BRACE.)

loy, is an alloy of about 99.44 per cent. pure copper, 0.45 per cent. chromium and 0.11 per cent. silver. After proper treatment, its hardness is about equal to that of carbon steel. In elastic limit, it also equals steel and surpasses the previous "tough pitch" hard-drawn copper about eight fold, and its "yield strength" and "ultimate tensile strength" are considerably above those of hot-rolled carbon steel. In both electrical and thermal conductivity Cupaloy has from 80 to 90 per cent. of the capacity of pure copper. Moreover, it retains these properties under prolonged temperatures up to 750 degrees F., whereas ordinary copper hardened by cold working softens in a few hours at a temperature of 400 degrees.

At once the question arises whether Cupaloy is simply a new alloy having properties interesting to scientists or whether it has valuable applications in industry. This question has been answered by Mr. P. H. Brace in a recent technical article published in the *Electrical Journal*. Among the several important uses of the alloy that he enumerates is that for welding electrodes. Since electrical welding is rapidly increasing, this use of the new alloy will illustrate why its properties are valuable. In ordinary welding the surfaces to be joined are raised in temperature to the fusing point by a blast of heat from some source, such as an oxyacetylene blow torch. In electrical welding the energy is carried to the material to be welded in the form of an electric current. It becomes heat where there is resistance to the flow of the current, namely, where the welding is to be performed.

Now why are welding electrodes of Cupaloy exceptionally satisfactory? In the first place, they hold their form under severe usage because of their hardness. In the second place, as a consequence of their high electrical conductivity, the electric energy flowing through them is not transformed in them into heat energy; it is transformed into heat in the materials having lower conductivity that are to be welded. In the next place, because of their high thermal conductivity the heat that is generated in them is rap-

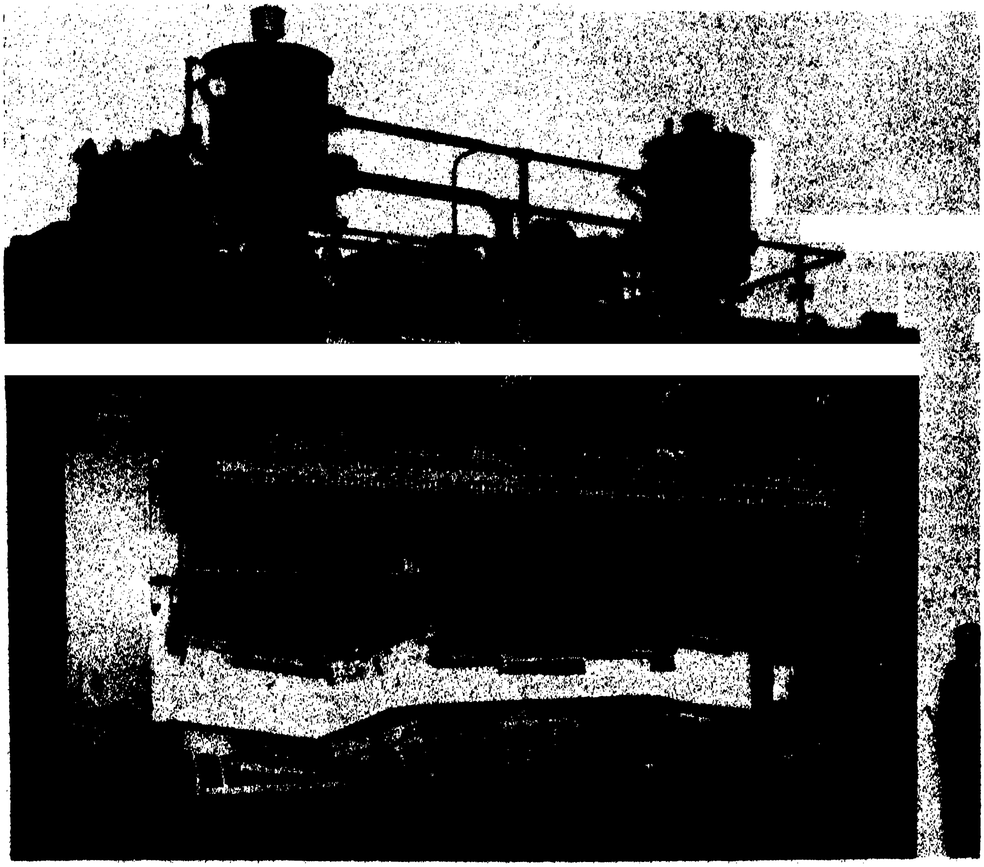


COPPER AND CHROMIUM
MODELS IN CUBICAL FORM. COPPER HAS AN ATOM AT EACH CORNER AND IN THE CENTER OF EACH FACE; CHROMIUM HAS AN ATOM AT EACH CORNER AND AT ITS CENTER. (BRACE.)

idly dissipated by conduction. Finally, they preserve all their desirable properties even under repeated and prolonged heating.

Until recently it would have been impossible to have found why Cupaloy has its remarkable properties, even if the combination of its components and the method of making it had been accidentally discovered. During recent years, however, the method of x-ray diffraction analysis of arrangements of atoms in crystals has been developed, the conclusions from which rest on the patterns of x-ray reflections by individual molecules interpreted by an abstruse theory. This remarkable and almost miraculous method reaches farther below the range of the microscope in exploring minute structures than the microscope reaches below the range of the unaided eye. For a time it was thought that the method was applicable only to regular lattice patterns. Now the theory of it has been developed to such a level that it is applicable to almost any molecular aggregation. Its promise of usefulness in exploring the mysteries of organic molecules and structural groups of molecules is almost dazzling.

Now let us return to copper and Cupaloy. It has been found that copper forms crystals out of unit "cells," as they are called, each of which is a cube with an atom at each corner and at the center of each face. Therefore, the unit "cell" contains twelve atoms in all, as is illustrated in the figure taken from Mr.

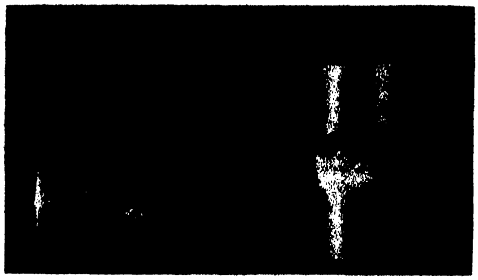


A LARGE WELDING PRESS USING CUPALOY WELDING ELECTRODES
FOR THE FABRICATION OF LARGE AND COMPLICATED AUTOMOBILE FRAMES. (BRACE.)

Brace's article. The length of an edge of one of these unit cubic cells is fourteen billionths of an inch (.000,000,014 inch). In pure copper these cells are normally arranged in crystals in an orderly fashion like bricks laid in a wall. When a piece of copper is deformed these crystals slide on one another in planes without great resistance to motion, because the atomic forces are largely used up within the "cells" and the crystals.

In the case of an alloy, "cells" of different dimensions, and sometimes of different patterns, are mixed. As it happens, chromium "cells" are also cubical, but they are smaller (.000,000,011 inch) than those of copper and consist of only nine atoms, one at each corner of the cube and one at its center. The atoms in "cells" of silver are arranged like those in "cells" of copper, but they are a little larger, having edges .00,00,016 inch in length. When different kinds of atoms are properly mixed some form crystalline particles which have the effect of a roughening of the planes on which the atoms are normally arranged. The condition is somewhat like that often encountered in mechanics in which a piece of metal, called a "key," locks together two plane pieces of metal which would otherwise slip on each other.

The problem of producing alloys having desired properties is generally much more than that of finding the proper ingredients and their proper proportions. The case of copper and chromium illustrates the point. At high temperatures the two metals are in solution, a relatively uniform heterogeneous mixture. When cooled slowly the chromium atoms gradually assemble into particles. If the process continues too far, many slip planes in



THE EFFECT OF PRESSING

A ROUND BAR OF CUPALOY CARRYING AN ENGRAVED INSIGNIA AGAINST A ROUNDED PIECE OF STRUCTURAL STEEL. THE CUPALOY WAS HARDER THAN THE STEEL. (BRACE.)

the copper crystals are left unroughened because the chromium crystals are relatively few and the alloy becomes softened and weakened. The problem is to discover the sequence of temperature changes, including sudden chilling, to produce the most advantageous sizes and distribution of the various crystals.

From what has been said it might be conjectured that if 0.45 per cent. of chromium produces a given amount of hardening in the copper then a greater amount of chromium would increase the property. Such is not the case. It may appear strange that less than one-half per cent. should produce the most favorable combination of properties of hardness and conductivity. But this brief account does not include all that is known about this problem, and all that is known is only a small part of what is desired. But the success in producing Cupaloy and other recent alloys, as well as the theoretical and practical means that have recently become available, indicates that metallurgy is still in its infancy, but that it gives promise of a rapid development and a glorious future.

F. R. MOULTON

"INFERIOR" CHILDREN IN SUPERIOR HOMES

EXPERIMENTS undertaken to assess the hereditary factors in sub-normal intelligence continue to give perplexing results. One of the latest of these is a study of 16 children of feeble-minded mothers who were placed in good foster homes shortly after birth, which is reported to the Society for Child Development of the Na-

tional Research Council from the State University of Iowa.

All these children are developing up to the normal level, according to Marie Skodak, of the university staff, who conducted the experiment.

The fathers of these children also were known and in nearly every case were worthless individuals. Both mothers and fathers, Miss Skodak says, "came of families distinguished for long records in welfare offices even during predepression years and for familiarity with various state and local penal, mental and charitable institutions."

All the babies were taken away from their mothers before they were 3 months old and placed in carefully selected middle-class homes. All were given standard intelligence examinations at two and a half and four and a half years. Miss Skodak expected that they would show up quite poorly. To the contrary they showed intelligence quotients almost identical with the average for children of the same ages.

The point has been raised, she says, that the mental development of these children will slow up rapidly as they enter adolescence so that they will revert nearly to the feeble-minded level when they are about 16. There is no evidence, she claims, for such sudden declines.

"The general conclusions which may be drawn from these results," she reports, "are that children of feeble-minded mothers and grossly inferior family background, when placed in average or superior foster homes at an early age, are indistinguishable in mental development from children whose mothers are not feeble-minded. The results indicate that if a child is physically normal and if the placement is made at so early an age that the child experiences only the environment of the foster home, the mental state of the mother ought to be no bar to adoption in a permanent foster home."

THOMAS HENRY

SLEEP LONGER

A TWO-HOUR nap may add as much as half an inch to a child's stature. This phenomenon, demonstrating the semi-elasticity of the human body, is reported to the Society for Child Development of the National Research Council by Drs. Janet M. Redfield and Howard V. Meredith, of the State University of Iowa. They made exact measurements on 22 children, 4 and 5 years old, in the university's nursery school.

The children had a rest period every afternoon. Some fell asleep regularly, while others lay awake on their cots. Both groups showed increases in stature, with the sleepers far in the lead. The average gain for the slumberers, they report, was a trifle less than half an inch, and almost 90 per cent. of this gain was between the hips and top of the head. Those who did not sleep gained about a quarter inch for each rest period.

The phenomenon is explained, they believe, by the constant pressure on the tissues of the body. The ribs constantly are being pressed closer together by the weight above them. This is especially true during vigorous play when the tissues are "shaken down." When the body is recumbent all this pressure is released, and the naturally elastic body returns to its greatest length. The explanation for the increased growth during sleep is that there is almost complete relaxation and hence no muscular resistance to the snap back.

Hitherto gains in height during sleep have been reported for individuals, chiefly adults. Some German investigators have found increases of almost an inch in adolescents.

The gains registered by the Iowa children, it was found, nearly all disappeared during the first two hours of play after their naps.

THOMAS HENRY

THE SCIENTIFIC MONTHLY

MAY, 1939

DRUG ADDICTION AS A PUBLIC HEALTH PROBLEM

By Dr. LAWRENCE KOLB
ASSISTANT SURGEON GENERAL, UNITED STATES PUBLIC HEALTH SERVICE

DRUG addiction is an engaging subject in the United States and a problem everywhere. Some countries pay less attention to it than we do, but all of them have more or less of it. It is a public health problem whose public health features have been obscured to some extent by laws designed to restrict the use of narcotics to medical purposes. The operation of these laws has in turn introduced other public health features having to do with the proper handling of persons who, in search of their favorite drug, are impelled to violate some law.

In a broad sense any drug that is regularly taken to produce unusual mental reactions rather than for a specific medical need is an addicting drug. There are many such drugs—some stimulating, some depressing and all harmful when used for non-medical purposes. The unusual reactions that these drugs produce are in the main pleasurable. By increasing physical and mental perception the stimulating drugs bring the addict into more intimate contact with the environment and give him an increased sense of power. By decreasing physical perception or the acuity of certain mental processes the depressing drugs enable the addict to escape from innate difficulties and disagreeable features or situations of the environment. The power to stimulate is not alone sufficient to make a drug attractive to addicts; there must be some distortion of function or sensation.

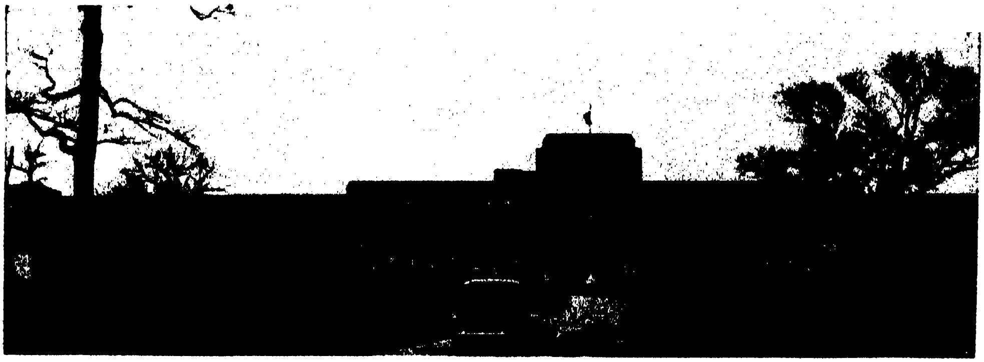
Strychnine is a powerful stimulant, but it has never been used for purposes of addiction. Cocaine, on the other hand, brings in an indefinite element that the addict is looking for, and it is the best example of a stimulating addicting drug. The depressive drugs act by producing mental and physical sedation or both. Some of the depressants, notably *cannabis indica* (marihuana), introduce an element of intoxication that is especially attractive to addicts, but may be, at least temporarily, terrifying. The sedative drugs, especially the hypnotics, may be merely stupefying. This is the reaction that many mentally distressed people seek, and with them it is a mild gesture towards complete oblivion in suicide. The stimulating drugs are more harmful, but the sedative drugs are more dangerous, because they are more attractive and more likely to cause addiction. Artificial stimulation eventually becomes unpleasant, but sedation is always pleasant; it is an answer to a universal human urge for peace and calm. We find, therefore, that the cocaine addict, becoming nervous, jumpy and apprehensive from increasing doses of cocaine, almost invariably changes over to opium when a prepara-

tion of this drug is available. He then discontinues cocaine or takes it only sporadically. Addiction to all drugs, including alcohol, has a natural tendency to gravitate toward some form of opium addiction. In an environment where different addicting drugs are equally accessible, many drunkards, marihuana addicts and cocaine addicts become opium addicts. Opium addiction is more attractive and more easily spread than addiction to any other drug. It is therefore more to be feared; and opium in its various forms is the drug that physicians and institutional, law-enforcement and health authorities usually have in mind when they speak of drug addiction.

Any preparation of opium that has pain-relieving properties will bring about physical addiction in any individual who takes it day after day. The time necessary to produce addiction depends upon the size and frequency of the dose and the method of administration. Smoking and eating opium are less dangerous forms of indulgence than the hypodermic or intravenous injection of morphine, heroin, dilaudid and other concentrated forms of the drug.

There are two reasons for the dangerous and seductive qualities of opium. First, it produces a sense of peace, calm and contentment without intoxication. Second, by its continued use the patient becomes tolerant to large doses, as well as dependent upon them for the maintenance of normal body functions and personal comfort. A certain degree of tolerance may be built up to increasing doses of many drugs, but opium is the only drug that produces dependence. A habitual user of morphine, the most important opium derivative, can in nine months build up tolerance from two quarter-grain doses per day to sixty grains per day, an amount sufficient to kill about fifteen unaddicted adults; but instead of being killed or seriously harmed by this large dose, the addict suffers intensely if he does not get it and may even die in collapse if the drug is abruptly taken from him. He becomes enslaved by his addiction, and it is this slavery that is so much feared. Both the stable and the unstable may become its victims. The physical slavery is the most spectacular thing about opium addiction, but it is not the most important thing with which the chronic relapsing addict has to contend. In a country like the United States, where opium can not be legally secured or prescribed except for medicinal purposes, the chronic addict is practically always an unstable individual, who is attracted to the drug by its soothing effect on his mind and his emotions.

The continued use of morphine brings about a certain amount of physical depletion; and this is especially marked if there is also regular or sporadic use of cocaine or some other narcotic. The deterioration in character produced in an individual by addiction results from several causes, such as the secrecy of the habit, the practice of evading issues and blotting them out with a narcotic instead of facing them openly, the parasitic life that so many addicts are compelled to live, the inevitable conflicts with the law, the undesirable social contacts that they must make in order to keep up the habit, the fact that so many of them must spend all their earnings to buy narcotics at exorbitant prices in the illegitimate market, and the physical harm resulting from alternating lethargy and physical and mental distress, due to too much narcotics one day and too little the next to maintain physical and mental comfort. Drug addiction is, therefore, a serious public health problem, as it undermines mental and physical health, forces users of narcotics into crime in order to keep up the habit which, for the time being, is vital to them, requires control measures to prevent spread, and imposes a burden upon the people as a result of criminal and other anti-social acts of addicts.



THE UNITED STATES PUBLIC HEALTH SERVICE HOSPITAL, LEXINGTON

Prevalence of Addiction

The drug habit is so strongly disapproved by society that an effort is always made to conceal it; and for this reason it has never been possible to secure an accurate census of the number of addicts in the United States. The Public Health Service made a careful survey of the situation in 1924 and concluded that in this country there were between 110,000 and 150,000 addicts to various forms of opium. Estimates made by the Bureau of Narcotics of the Treasury Department indicate that the number has decreased since that time, but marihuana addiction has lately come into the picture and is now being given serious attention by health authorities and law enforcement officers.

It was not until the latter part of the past century that the public conscience became aroused to the evils of drug addiction. Opiates were widely used by physicians for conditions for which they are not now prescribed, and until 1914 narcotics could be legally bought practically anywhere without a prescription. As a result, the incidence of addiction was much higher than it is to-day. Opium used for smoking was legally imported as late as 1909, and it is not unusual to find an addict to-day who started smoking in a legitimate opium den in order to find out first-hand what the effects might be. Before the advent of narcotic regulations, addiction among women was more prevalent than among men. The ratio from 1900 to 1915, when preparations containing opiates could be legally bought without a physician's prescription, was about two women to one man. It is now at least four men to one woman. Women, leading a more secluded and sedentary life and having fewer social outlets than men, unwittingly addicted themselves by self-medication for real or imaginary ills, the latter often based on introspection. But women are more law-abiding and they get into less tempting environments than men. As a result of these factors, addicted women were cured in great numbers and non-addicted women avoided illegal contacts after the passage of narcotic laws, while the men continued in spite of the law to satisfy their cravings and impulses to dissipation.

Addicts may be divided into nervously normal and nervously abnormal, or unstable individuals. The former were once quite common, but are now rare. The abnormal individual gets unusual sensations and pleasure from narcotics, especially opiates. He is normally in an emotional turmoil, with strivings and impulses that he does not understand. Morphine or heroin brings surcease from these emotional conflicts and disturbances for the time being and makes the afflicted indi-

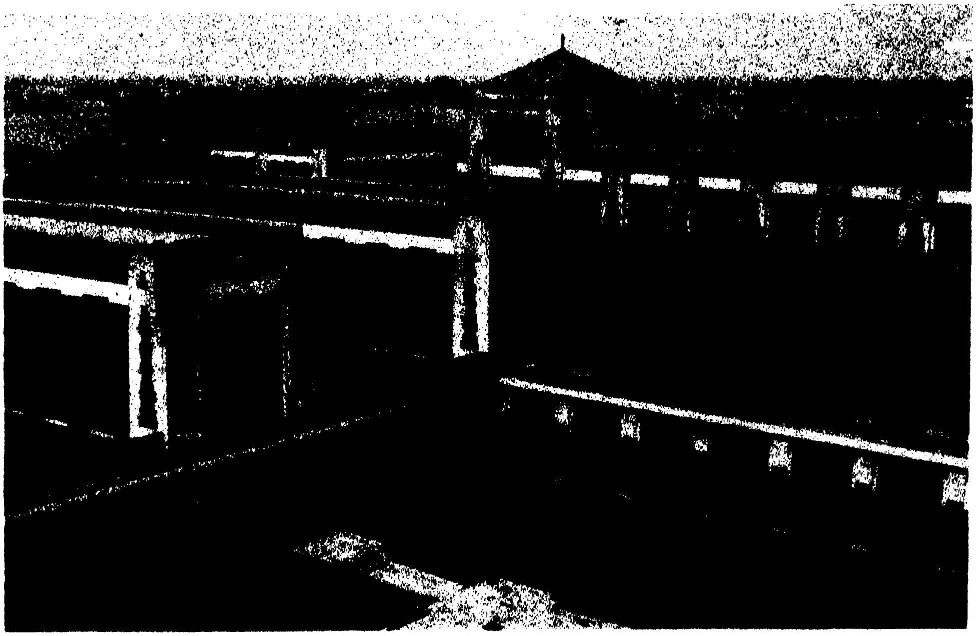
vidual feel like a normal person. Becoming addicted and finding that the remedy was only temporary and illusive, he seeks cure, but relapses again because his emotional difficulties have not been corrected or properly interpreted to him. He does not understand why, but he goes back again to narcotics because he remembers the relief that they gave him previously.

The emotionally unstable individual who is so susceptible to addiction has impulses and strivings abnormal in kind or degree; he is reaching out for something that he does not understand and can not attain. As a result he feels restless, discontented and inferior. Morphine, by narcotizing certain functions, gives him a sense of ease, contentment and confidence. The contrast with his former self is so great that it is interpreted as pleasure. The subject formerly was afraid to attack his problems. He now knows that he could solve them, but the new-found ease and calm are so satisfactory that he feels there is no necessity to do anything about them. The solution is, however, only temporary. As the effect of the morphine wears off, he drops as far below his normal emotional plane as the drug buoyed him above it, and he must repeat and increase the doses in order to recapture the pleasing sensation that he had previously experienced. Thus he becomes a chronic relapser, and more than likely a parasite on his friends. He also often becomes a petty thief because, while physically addicted, satisfaction of the physical craving has become the most important thing in life for him.

The addict most to be pitied is the neurotic who has acquired physical addiction through having been given morphine for some chronic condition that is not completely curable but which does not call for continued use of the drug. More important, he becomes mentally addicted. He does not understand this, and rationalizes the continued use of the drug as necessary for his physical disease when, as a matter of fact, he uses it for the mental condition which it can never cure. Another large group of mildly unstable psychopathic individuals, who might otherwise be useful, take the drug for the same reason and thereby ruin their lives.

The opium habit is always harmful, but it is consistent with reasonable health and efficiency, and in the past many useful and even prominent people have been afflicted with it. Some chronic drunkards have accidentally lifted themselves out of the gutter by substituting the opium for the alcohol habit. The shift for them was from a greater to a lesser evil.

Tolerance to and the physical dependence upon opium together form one of the most interesting and baffling problems in medicine. The fundamental mechanism by which the body cells protect themselves from enormous doses of this drug, in such a way that when not bathed in it their functions may become so disturbed as to cause death, is not understood. There have been many theories to explain this phenomenon of tolerance and dependence, but none is adequate and all the treatments based upon them have been failures. The following are important among the theories that have been advanced: That the abstinence symptoms are due to a toxemia; that there is a rearrangement of the water molecule within the cell that protects it from morphine and causes a disturbance when the drug is withdrawn; that the lipoids of nervous tissue are dissolved by morphine, making the nerves more sensitive to stimuli; that morphine causes the development of immune bodies that protect the cells during addiction and poison them when the drug is withdrawn; that the withdrawal symptoms are a condition of anaphylactic shock



SECTION OF THE MAIN COURT OF THE HOSPITAL
A SOLARIUM AND WALKWAY FOR TUBERCULAR AND OTHER PHYSICALLY ILL PATIENTS IS SHOWN ABOVE UPPER STORY ON THE RIGHT.

produced by the union of an antigen and anti-bodies which, in the absence of morphine, unite and produce shock; that the drug normally combines with a sensitive cell receptor, producing euphoria, but stimulating the formation of additional receptors that, in the absence of morphine, are combined with by a stimulating hormone, with consequent overstimulation and the withdrawal symptoms that there is disturbance in the water balance during addiction and withdrawal; and other less important theories. In addition to the treatments based upon these theories, there have been numerous empirical treatments for which much has been claimed. It is unlikely, however, that any specific treatment for the withdrawal symptoms or morphine addiction will be discovered until the mechanism of physical addiction is adequately explained.

The preventive measures for the control of addiction consist largely of laws and regulations designed to restrict the use of narcotics to medicinal and scientific purposes. These laws are adequate and effective in so far as repressive measures are concerned. They have resulted in protecting people from addiction and in causing numbers of addicts to seek cure; but they are not the complete answer to the problem. Physicians are now very careful in prescribing narcotics; but they sometimes necessarily or unwittingly introduce unstable people to morphine, who thereafter seek the drug in spite of warnings. In order to reduce the danger of prescribing the narcotic drugs, the American Medical Association has published a series of papers on "The Indispensable Use of Narcotics," which are designed to orient physicians so that they limit the use of these drugs as far as possible. For the same purpose the United States Public Health Service is cooperating with other groups in a study to determine the amount of morphine or co-

THE TAILOR SHOP
ALL CLOTHING USED BY THE PATIENTS, INCLUDING GOING-OUT SUITS AND OVERCOATS, IS MADE HERE.

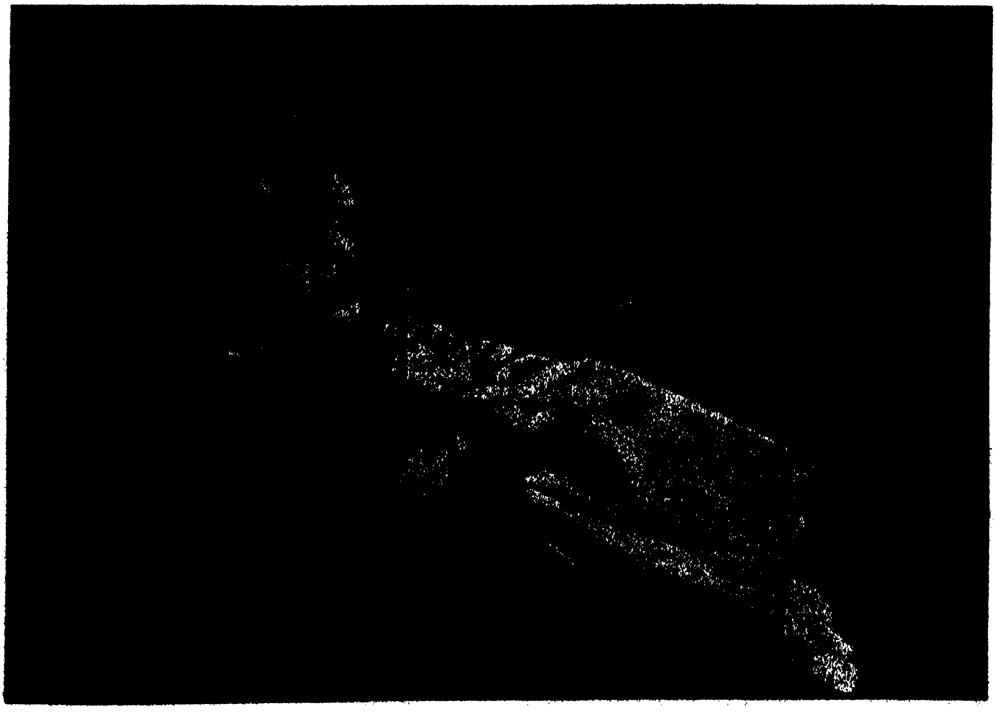
deine sufficient to control cough. These studies indicate that codeine, which is less addicting than morphine, controls cough as much as drugs may be expected to control it and that much smaller doses than were formerly used give good results. Many tuberculous patients have been addicted to morphine through having it prescribed for cough, and studies at the Lexington hospital show that these patients, if not in an advanced stage of the disease, gain weight and do much better generally when morphine is withdrawn.

The treatment of drug addicts has become a serious public health matter, and it is complicated by the enforcement of laws necessary to control the distribution of narcotics. The most important of these laws, the Harrison Narcotic Act, has been effective in controlling the manufacture and sale of narcotics in legitimate trade, but it made no provision for the medicinal treatment of addicts who violated the law. Thousands of these were at first sent to prison, where their real needs were neglected. They were treated there as prisoners deserving punishment rather than as patients who needed treatment. As a rule, they easily recovered from their physical addiction, but their emotional attitude toward the situation was made worse by the sense of injustice that had been done them and by the general harshness and barrenness of the prison environment. The result was, too often, prompt relapse on discharge, with a vicious circle of other violations and prison confinements that continued the ruin started by narcotics.

The injustice and futility of this method of handling addicts became more

and more apparent, and in 1929 the serious defect in the original law was corrected by the passage of an act establishing two narcotic farms, now known as United States Public Health Service Hospitals. One of these hospitals is located at Lexington, Kentucky, and the other at Fort Worth, Texas. The purpose of these institutions is to study and disseminate information about drug addiction and to rehabilitate and teach to be self-supporting and self-reliant addicts who are admitted to them. A convicted federal addict offender may now be sent to one of these hospitals instead of to prison; but, more important still, the court is empowered to place such offenders on probation, a condition of the probation being that they enter one of these hospitals for treatment and stay until cured. By this measure the addict is saved from the stigma of a penitentiary sentence and is given treatment under a mild form of restraint, which he usually needs. These hospitals are also authorized to treat voluntary patients. This is important, because the average addict is not financially able to secure treatment in sanitariums, and the general hospitals that accept such patients only irritate them by a short period of treatment that, as a rule, leaves them worse than they were before they entered. Often repeated fruitless treatments, with immediate relapse, are more harmful to the physical well-being of addicts than no treatment at all. Successful treatment involves two important procedures—cure of the physical need for the drug and cure of the mental condition that makes it so attractive.

The narcotic hospitals holds the convicted addict as a prisoner, but treat him as a patient. The hospitals' approach to



TESTING EMOTIONAL RESPONSE OF SUBJECT TO PSYCHOLOGICAL STIMULI UNDER NORMAL CONDITIONS AND UNDER THE INFLUENCE OF MORPHINE, ON THE BEHAVIOR PHOTO-POLYGRAPH IN THE PSYCHOLOGICAL LABORATORY OF THE LEXINGTON HOSPITAL.

the treatment problem is based on the assumption that, while physical addiction is a very important thing that must be cured, the psychological angles of the case are much more important, and on the belief that if the patient is to achieve permanent cure he must be relieved of his emotional difficulties or taught to adjust to them without resort to narcotics. The aim is to give the patient a new outlook on life and to build up a new set of habit patterns so that he can resist the impact of former associations and temptation when it is not possible to avoid them. The first step in the mental readjustment of the patient is the treatment of the physical withdrawal symptoms. By neglect or an unsympathetic approach during this phase of the treatment, mental scars may be made that are difficult to remove. The withdrawal period is a difficult one for the patient. If his habit is strong, he suffers intensely, and if not properly treated he may collapse and die. Restlessness, tremors, muscular twitchings, insomnia, nausea, vomiting, pains and feelings of weakness, nervousness and insecurity cause many to fear death. An added mental depression leads others to attempt suicide. These symptoms should not be made light of and ignored. Addicts under treatment practically always ask for morphine, and practically always safely get over the withdrawal period regardless of whether or not they are given morphine or any other kind of treatment. For this reason they are thought by some to simulate the symptoms or grossly exaggerate them. That the symptoms are real is shown by the fact that morphine addicted animals, especially monkeys and dogs, suffer with them. The author injected increasing doses of morphine into a number of monkeys twice daily for nine months, and then abruptly discontinued it. One animal died, several others developed serious symptoms of collapse, but recovered, and all of them showed unmistakable signs of physical depression and suffering.

Unfortunately, some addicts have been killed by unscientific treatment or by neglect and indifference, based on the conception that addicts are criminals who should be allowed to suffer. It has even been regarded as a sort of sin to give morphine to an addict in withdrawal, and the author knows of several instances in which addicts died as a result of treatment based on this falsely pious attitude.

At the narcotic hospitals all types of specific withdrawal treatments have been discarded as harmful or useless. An effort is made to gain the confidence of the patient by approaching his problem with a sympathetic attitude. The morphine is then rapidly withdrawn and supportive measures are employed that are designed to reduce the severity of the symptoms and avoid collapse. By these methods the worst of the withdrawal symptoms are relieved in from ten days to two weeks, and a start has been made on the psychological readjustment. Time is an important element in treatment. Some, mostly accidental medical addicts, have been permanently cured in a few weeks; but cure of the unstable patient in such a short time is not to be expected. Work done in the research laboratory at Lexington shows that some of the physical functions, disordered by the long-continued use of morphine, do not return to normal for months after the drug has been discontinued. During this period the patient is naturally more susceptible to relapse for physical reasons.

Time is more important for the successful treatment of the mental habit than for that of the physical addiction. The addict, even if he has sufficient narcotics, becomes uncomfortable several times a day when the last dose wears down. If another dose is not available, he suffers acute distress in about eighteen hours. Over a period of years he relieves such

discomfort or distress thousands of times by injections of morphine. During this same period he enjoys the drug in pleasurable associations with friends and by taking it to get the effect that many of them describe by the statement "It makes my troubles roll off my mind." By thus building up a strong association between pleasure and pain and the taking of a narcotic he becomes conditioned to taking one in response to most any situation that may arise. It may be because of some minor physical discomfort or because he meets a friend or feels so happy over being cured. By being compelled for months to adjust to all situations without narcotics he becomes unconditioned, so that he is able to give at least intelligent resistance to narcotic suggestions. In addition to this unconditioning, and as a substitute for old habits, new habits must be built up; and for this reason the addict under treatment should be kept busy in some useful way during all his waking hours. At the narcotic hospitals this is done through the means of work on the farm and in shops and by reading and recreation. Some patients are benefited by intensive psychotherapy that is designed to give them a better understanding of themselves and their weaknesses, and all of them receive at least a minimum amount of psychotherapy. By these means new habit patterns are built up, a new outlook on life is formed, the patient is made better to understand himself, and he goes out prepared to face and fight his problems rather than to evade them by the use of narcotics. It is important, too, that he should leave without resentment, feeling that he has not been punished unnecessarily, but that an effort has been made to do something for him. The effort often fails. The strength of the habit and the human material from which addicts are recruited makes this inevitable, but permanent cure has been achieved in a large proportion of cases. The importance of resentment as a barrier to cure is shown by prisoners who, complaining of the injustice of their confinement for four years, promptly relapse on being discharged and then return as voluntary patients and cooperate in the treatment.

OUTSIDE THE METABOLISM CHAMBER

THE PHYSICIAN IS TELEPHONING TO PATIENT WHILE OBSERVING HIM THROUGH THE CHAMBER WINDOW. IT IS AN ABSOLUTELY AIR-TIGHT CHAMBER IN WHICH THE PATIENT IS KEPT FOR TWENTY-FOUR HOURS. ALL FOOD, WATER AND AIR THAT HE TAKES IN AND ALL EXCRETIONS, INCLUDING PERSPIRATION AND EXPIRED AIR, ARE MINUTELY MEASURED. COMPARISONS ARE MADE ON THE SAME SUBJECT DURING AND AFTER ADDICTION TO MORPHINE. EVERY MOTION OF THE PATIENT IS RECORDED ON A MOVING DRUM.

Addiction to marihuana and cocaine have the same psychological implications in so far as etiology is concerned as addiction to opium. Addiction to these drugs is much more likely to lead to positive criminal acts, based on stimulation and bizarre mental reactions. Addiction to them is, therefore, more of a police problem than is addiction to opium. The latter brings about only negative crimes, motivated by physical necessity. The treatment of addiction to the other drugs is, however, the same as the treatment of addiction to opium, minus the necessity for special attention to physical dependence.

Everything possible in the way of narcotic regulation is being done to prevent people from becoming addicts, and much is being done towards improving the lot of addicts themselves, but much more needs to be done. It is important that the public be informed as to the exact importance of drug addiction in its relation to other things, so that the addict may be regarded not necessarily as a criminal, but as a sick person, who needs more attention from the physician and less from the police. Drug addiction should be treated as one phase of a general program for improving the mental and physical health of the people. More treatment facilities are needed, especially for women. It is a reflection on our society and our government that some addicts, unable to get treatment elsewhere, ask to be sent to prison for a cure. When the addict leaves the hospital or prison, he should be given an equal chance with others to secure work, as enforced idleness and unfounded suspicion directed toward him are among the most potent causes for relapse.

A long-time research into the fundamental nature of opium addiction is desirable. A start has been made on this at the laboratory of the Public Health Service hospital at Lexington, where metabolic, biochemical, electroencephalographic, psychological and other studies are being carried on. There is also in progress a research designed to develop a drug that has the pain-relieving properties of morphine, minus its addicting qualities. This investigation is being conducted by the Public Health Service in cooperation with the Committee on Drug Addiction of the National Research Council and other agencies. The goal of these various measures is to prevent and to cure addiction, just as the goal of other public health activities is to prevent and cure other physical and mental ills that beset mankind.

UP MOUNT KINABALU

I. White Man and Natives Begin Ascent

By JOHN A. GRISWOLD, JR.

RESEARCH ASSISTANT, MUSEUM OF COMPARATIVE ZOOLOGY, HARVARD UNIVERSITY; MEMBER OF THE ASIATIC PRIMATE EXPEDITION.[1]

Mt. Kinabalu in British North Borneo is the highest mountain in Malaysia, its loftiest peak, Low's by name, reaching a height of 13,455 feet. There is no other physical feature in the whole of North Borneo that is so striking or so awe-inspiring, both to whites and natives alike. To the zoologist, especially the ornithologist, it is of the greatest interest.

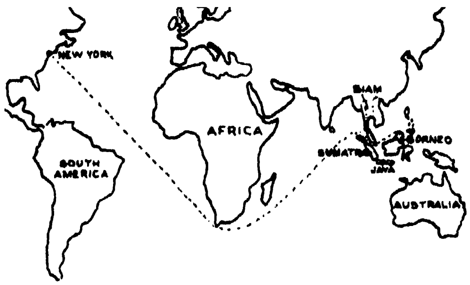
Kinabalu stands twenty-five miles from the coast, and can be seen a hundred miles out to sea. The mountain itself consists of a system of ridges, the exact relationships of which have never been worked out. Therefore, it is hard to say exactly when one really starts climbing the granite mountain which is inaccessible on all but the north side.

The mountain was first climbed by Hugh Low in 1851 and since then by many visitors. The majority of these travelers were naturalists, and to the credit of one of them, John Whitehead, are over sixty new species of birds besides many mammals. It was for this reason and its accessibility that it was decided I should collect there.

On my arrival in Jesselton I at once

[1] This cooperative expedition organized by Harold J. Coolidge, Jr. of the Harvard Museum of Comparative Zoology made documented collections of primate material, behavior studies on wild primates (especially the gibbon), and general zoological collections in the mountains of Northern Siam and in British North Borneo.

MOUNT KINABALU



THE AUTHOR'S ROUTE TO BORNEO

paid a call on the Resident, Mr. Evans, who, already having been notified of my intentions, had engaged a cook for me. It was mainly through his assistance that my trip was made possible and the burden of the journey made easier. He gave me valuable information, engaged the services of an interpreter and arranged porters for the first day of the five-day trip inland, in addition to procuring "bonguns," the native basket that is ideal for carrying one's supplies.

Mr. Evans also introduced me to George Moffatt, head of the Government Audit Office, who was of the greatest help to me while I was on the mountain. It was he who forwarded my mail and the extra supplies I needed by a system of weekly mail runners.

The week I spent in Jesselton was a hectic one, what with sorting equipment,

DUSUN PORTER

WITH A BONGUN ON HIS BACK, AND CHINESE SKINNER SHIM TIAM FOOK JUST BEYOND HIM.

purchasing food, blankets and other necessary articles, as well as interviewing prospective camp coolies and a man to help me with the skinning.

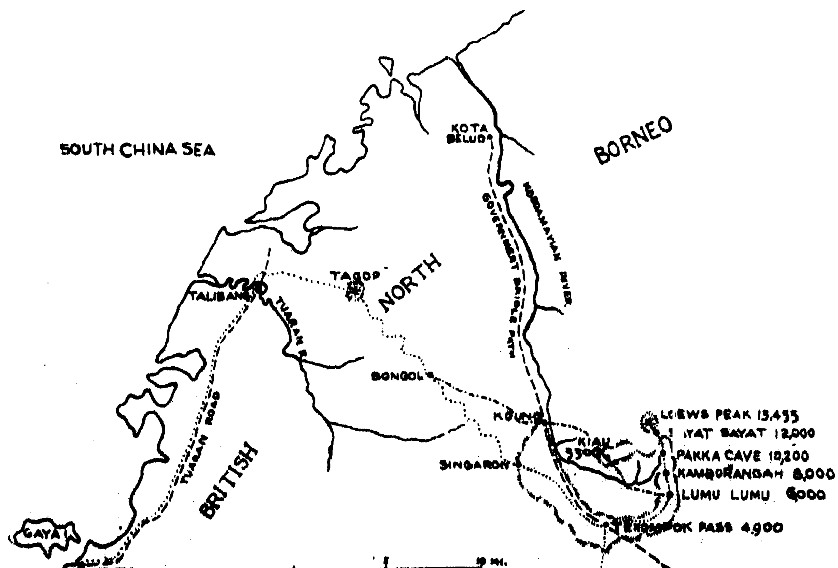
My final retinue was as follows: Mohamed Ali, interpreter; Andu Majanon, cook; Magunjang, camp coolie; and Shim Tiam Fook, skinner. Shim Tiam Fook had never skinned a bird in his life and only one monkey that I shot to try him out. He was so conscientious and did so well that I decided to take him on. He subsequently became an excellent skinner and proved the wisdom of my judgment. He was a thoroughly nice chap, hard-working, polite and with a good deal of authority over the natives.

I had decided to make our first collecting camp at Lumu Lumu at an altitude of 5,500 feet, which is the next to last stopping point before the summit is reached.

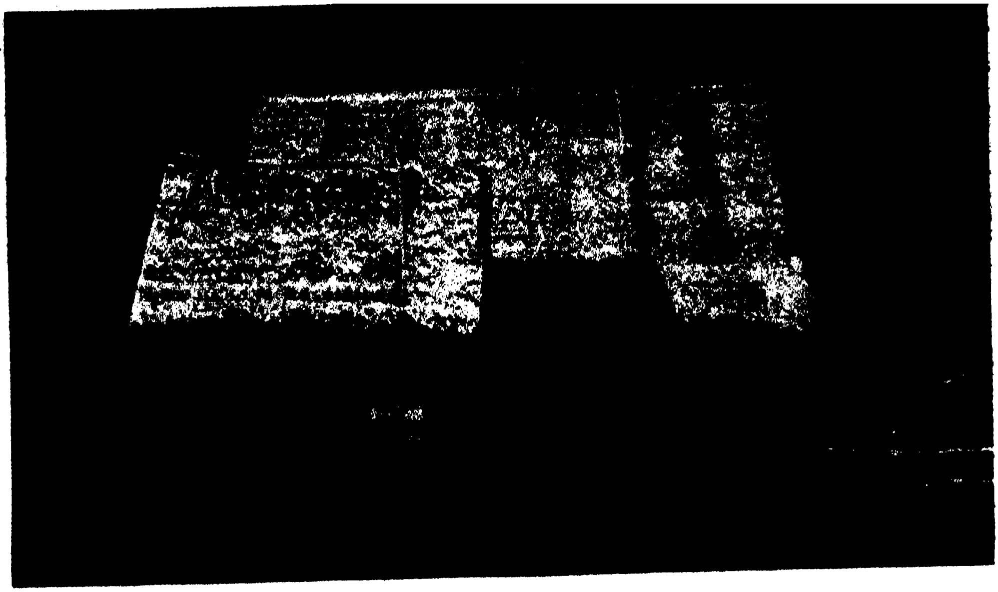
The morning of May 31st was set for our departure. The day before I had arranged for two buses to call for us at the Government Rest House at 6 A. M. At 9:30 we arrived at Talibong, where I was met by the local chief, thirty-four porters and a Government policeman. After an hour and a half of general scramble by the porters for the lightest and most convenient loads to carry and then a search for bark to make carrying straps and to tie the loads, we finally got started.

I had learned from previous experience that the quickest and most efficient system is to make up the loads yourself so that they all weigh approximately the same, and then let the porters decide amongst themselves what each is to carry. It then becomes only a question of keeping a weather eye open to see that nobody lightens his load by hiding a box or tin behind a tree, to be discovered when you are all ready to start, because there will follow a heated argument when you try to add it to the load of one of the porters.

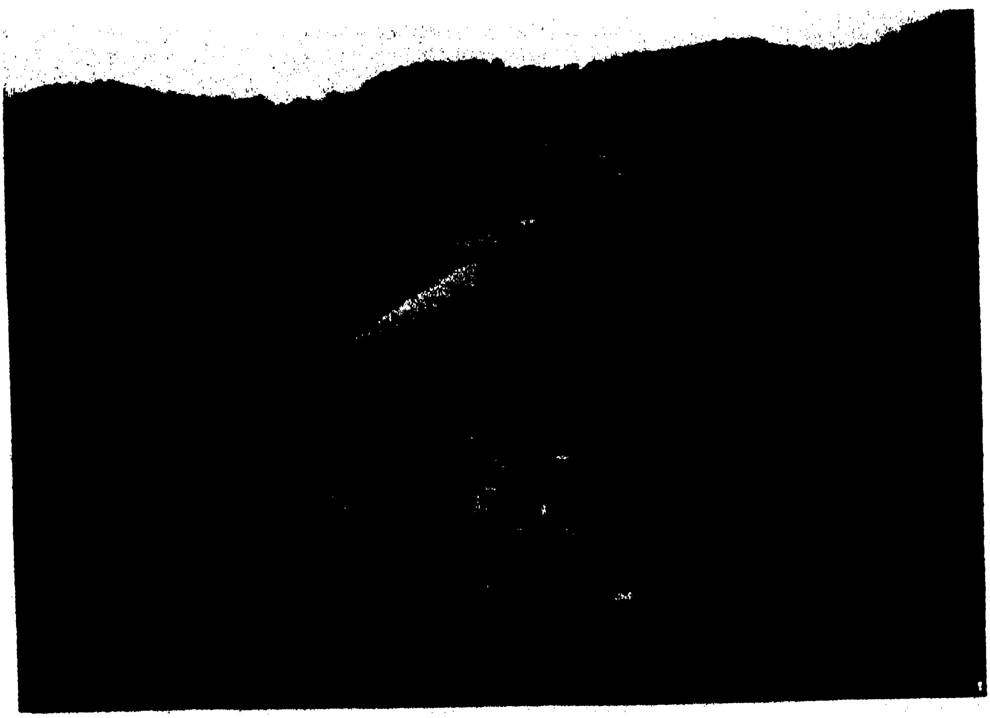
MAP OF THE EAST INDIES
SHOWING MOUNT KINABALU AND ROUTE FOLLOWED.



DETAIL MAP OF MOUNT KINABALU,
TO SHOW ROUTES TAKEN BY THE AUTHOR. . . . . INGOING ROUTE; -.-.-.- OUTGOING ROUTE.
MODIFIED FROM F.M.S. SURVEY NO. 149. 1932.



THE LARGE GOVERNMENT RESTHOUSE AT BUNDUTUAN



BUNDUTUAN VILLAGE AS SEEN FROM THE RESTHOUSE

Crossing the Tuaran River, we left the road for a narrow trail along its left bank through cultivated land and bamboo groves. Fifteen minutes later we stopped to let the stragglers catch up and the men adjust their loads. Since this was also the last place the porters could obtain water before reaching our destination, many of them cut sections of bamboo which they filled with water and strapped them to their loads. It was an hour before the last porter caught up with us, his load falling apart. Some of the more experienced carriers set about adjusting his burden, while the others jeered at the poor fellow.

At last we got started and made good progress for about two hours, when again we were further delayed by the same man's lagging behind. This time, however, the cause was much more serious. I found that only recently he had recovered from an attack of beriberi, and that he had not regained his strength sufficiently for such strenuous work. He staggered along the trail at a very slow pace and whenever he came to a log across the path it was all he could do to step over it, his skinny legs quivering like a branch that is caught in a rushing stream. I lightened his load considerably, but even then he seemed so exhausted that I finally had my camp coolie carry his load.

MOUNT KINABALU FROM 3,300 FEET, AND COOK ANDU

At one of our many halts beside a small river my pet monkey "Minnie," that I had brought from Siam, surprised me by voluntarily going swimming. She would jump from the four-foot bank into the deep water, completely submerging and then swim against the current to the shore. This act she repeated several times, apparently enjoying it immensely.

At five o'clock, after a steep climb in the rain, we arrived at the kompong, or village, of Tegop, perched on the side of a hill. We passed through the village to its outskirts, where we found the Government Rest House, a small bamboo structure with a palm-leaf roof, all raised some four feet off the ground. From here we had a wonderful view of the village with its beautiful green grass, its coconut palms and native huts. Far be-

LAW ENFORCEMENT
A NATIVE POLICEMAN AND GOVERNMENT DRESSER.

TENOMPOK PASS,
4,900 FEET. CAMP COOLIE MAGUNJANG, WITH MINNIE ON HIS SHOULDER.

low the valley stretched down towards the ocean, which was just visible through the clouds and haze.

Early next morning I relieved three of my porters on account of sickness and injuries incurred on the way. Each man was paid $.35 Bornean currency for his day's work, which is equivalent in purchasing power to $18 in America. We left Tegop at 7 A. M. for Bongol, four porters and I arriving there in the early afternoon. The Rest House was situated near a small stream in an open field. At 4:30 most of the porters and my men reached the river, having missed their way. They had to cross it before climbing the bank to the Rest House, but what had been a shallow and gently flowing stream was now a deep and rushing torrent. After repeated attempts, Ali, my interpreter, swam across with a large vine attached to his belt. With this vine as a starter, we were able to construct a temporary bridge and get the porters over safely.

Early the following morning I went down to the now subsided river to take a bath. It was not yet light, but I could see the vague outlines of nightjars as they coursed up and down stream, passing a few feet above my head. As I returned to the Rest House the day suddenly broke and there, appearing so near but yet so far away, towered Kinabalu, majestic and almost terrifying in the early morning light. It was not hard to see why the natives held it in such veneration and considered it to be the resting place of their souls after death, and only to be visited by those who took with them a priest to perform adequate sacrifices and prayers.

At seven o'clock the new porters straggled in, eight of whom were girls and old women. One man wore only a loin cloth and a bark shirt, which was ideal for such hot work as carrying. This day's trip to Singaron was made miser-

DUSUN PORTERS AT TENOMPOK PASS, ELEVATION 4,900 FEET

able by continual rain all the afternoon, for the steep trails turned into rushing streams and the path was very slippery. By the time we arrived there I was covered from head to foot with mud and my pith helmet had several dents in it, as did my cigarette case, which I had put under my helmet to keep it dry.

The Singaron Rest House was more or less like the first one, but its roof leaked

A CROWD OF NATIVES AT TENOMPOK MARKET

BUYING AND SELLING AT THE TENOMPOK MARKET

badly. So I sent for the local chief, who had it patched with banana leaves by his two naked and dirty sons. I also asked him for ten porters for the following morning, because all the women wished to return to Bongol. Towards evening I toured the kompong and bought eggs for 1 cent apiece, four bananas for one cent, two chickens for thirty cents, as well as tapioca and potatoes at corresponding prices.

Next day my interpreter and I, with a guide, made a quick march to Kiau, a large village of over three hundred people, where I could secure the necessary porters, priest and guide for climbing the mysterious mountain. My staff with the rest of the porters were to proceed to Tenompok, where we would spend the night.

I was under the impression that Tinompok was a village, but subsequently discovered it to be only a pass at 4,900 feet, which the Government Bridle Path crosses. The Bridle Path runs from Kotabelud, a large town on the seacoast in the interior. It not only affords government officials a quick and easy means

of entering the interior but enables the natives to get their products down to the coast for sale, chief of which are rice and tobacco.

The trail to Kiau and from there to Tenompok was much longer than I expected it to be and was one of the most difficult and arduous walks I have ever taken, being steep downhill grades and still steeper and longer uphill grades. It is because of this roller-coaster-like country that it takes so long to cover a

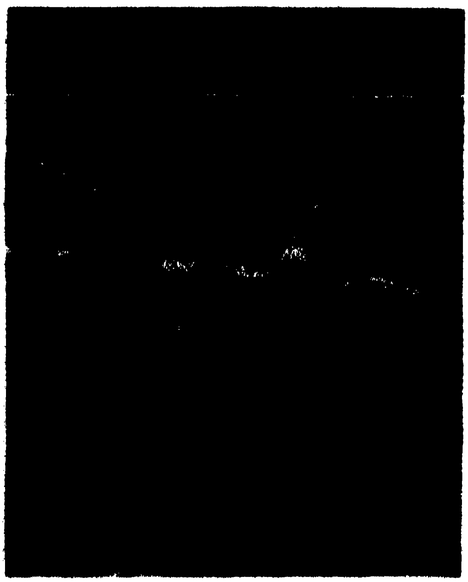
MACAQUE MONKEYS AT LUMU LUMU
MINNIE HAS BABY PISANG IN HER ARMS; KINA IS AT THE RIGHT.

short distance. A mile as the crow flies is at least six miles by trail.

In the valley below Kiau we crossed the Kadamaian River by a seventy-foot span bridge of bamboo. We then toiled up the last, longest and steepest hill in the heat of the midday sun. At Kiau I met Derensai, the high priest, with whom I had a long talk about ascending the mountain, expenses for sacrifices and guide and porter fees. I also arranged to have him send thirty-seven porters to go up to Lumu Lumu, as well as two extra men to act as mail messengers to Jesselton.

HOMEWARD BOUND

At Kiau I visited one of the long houses where about ten families live together. In this long house I saw an old "parang," or native sword, that the natives once used for cutting off the heads of their neighbors, when they went on head-hunting expeditions. Ten minu-



NATIVE HUNTER WITH HIS BLOWPIPE

tes' dickering and I had bought it for five Borneo dollars.

Leaving Kiau we again descended the steep hill to the Kadamaian River, where we came across a group of men and women wailing in the most dismal tones. Our guide was terrified and ran down to the river and crossed another bamboo bridge. When we finally caught up with him he told us that one of the people in this mournful procession had dysentery and that the victim was being escorted to the river in order to wash the bad spirits away. At this moment, the group appearing on the opposite bank, our guide fled up the narrow trail, still fearing that the evil spirits would bewitch him, while Ali and I remained to see the priest make a sacrifice and the sick man cleanse himself in the rushing water. This was a perfect example of the way dysentery is spread and an obvious reason for boiling all drinking water.

Along the trail we saw several groups of macaque monkeys (*Macaca irus*), and at Tenompok pass I was thrilled by my first glimpse of an iridescent green bird that flew swiftly over our heads. This was Whitehead's broadbill (*Calyptomena whiteheadi*), which is indigenous to the tall, damp forests of Kinabalu between the altitudes of 4,000 and 5,000 feet.

The Bundutuan Rest House, where we were destined to spend the next three days, was almost palatial. It was very large, with two separate bedrooms and another large room with a stone fireplace. The floor was of roughly hewn

MY CAMP AT LUMU LUMU, 5,500 FEET

'A COLDER AND DAMPER AND MORE MISERABLE PLACE I HAVE NEVER BEEN IN.'

LIKE SO MANY MEDIEVAL TOWERS, 12,500 FEET

boards, the sides of bark and the roof of leaves sewn to sticks six feet long, which were overlapped to form shingles. The house was of course raised some feet from the ground. An adjoining house served as a kitchen, where running water was supplied by long pieces of bamboo to form a miniature aqueduct. The entire place was surrounded by a corral, with a stable at one corner. Rest houses of this magnitude are found on every day's journey along the Bridle Path.

It was here that my guide, Labuan, joined us. Although he was only a boy in his teens, frail-looking and quiet, all the natives respected and obeyed him. He had guided many parties up the mountain and was, in fact, the only one who knew the trails well.

Labuan informed me that unless I had tents it would be impossible to have a waterproof shelter at Lumu Lumu, for there was nothing with which to make a roof. This was indeed disconcerting news, for I only had one small tent and one tent fly. The only solution appeared to be to gather "Kabu" leaves and carry them up to Lumu Lumu. We bought the 2,000 which would be required for the equivalent of one American dollar.

The following day the porters carried up some of our loads, as well as the leaves, to the camp site at Lumu Lumu. They were to spend two days in building a shelter and then return to carry up the remainder of our equipment. During this time I did active collecting. The Dusun villagers soon discovering what I had come for, numerous children constantly arrived with beetles, grasshoppers and lizards ingeniously strung on pieces of rattan which, with bamboo, is so valuable to these people. In fact, given these two materials and a knife, a Dusun can make almost anything.

The Dusuns are indigenous to Borneo and one of the most predominant races. "Dusun" is a Malay word meaning "orchard or village or collection of houses." The name has now been loosely applied

CLOSE-UP OF CAMP AT LUMU LUMU
SKINNER AH FOOK ON THE LEFT, AND INTERPRETER CHANG AH TET ON THE RIGHT.

to this group of people. They are animists, worshipping and fearing the more or less hostile spirits of mountains, rocks, trees and their ancestors. They are very superstitious, having great faith in omens like the call of the woodpeckers. Although the Dusuns are administered under the Indian Penal Code, matters of marriage, debts, inheritance and divorces are wisely left to their own laws. They usually have one wife, and divorces are not infrequent.

END VIEW OF CAMP AT LUMU LUMU

The villages are usually beautiful places, with attractive bamboo houses, tall and stately palm trees and lawns of the greenest grass, kept like a tennis court by grazing buffaloes. The houses, whatever their size, are all built on the same principle. The largest one I visited, sheltering more than forty persons of different families, was about 120 feet long, with floor of bamboo and roof of palm leaves. The entrance to the floor, about five feet above the ground, was at one end and reached by a sort of narrow gangplank. There were no windows, but there were slits cut in the wall at frequent intervals.

One side of the house is partitioned off into private sleeping and cooking quarters, in the form of cubicles, for each family. The other side is a vast common room. The house was comparatively clean and the floor was polished by the bare feet of its occupants, whose daily life is epitomized by the large collection of their various belongings, scattered about everywhere. Large glazed jars, arranged along one side, contained rice and rice toddy. Baskets, hats, traps and other numerous bamboo and rattan articles were piled in corners, hung on pegs or stored in a sort of attic. Underneath the house pigs grunted, chickens scratched and mangy dogs lolled, while beehives hung from under the eaves.

The wealth of a Dusun family is not judged by the number of pigs or buffaloes, but by the number and quality of its gongs. An "A-I" gong is known as a "China Kimanis" and might be worth as much as 200 to 700 American dollars. Some years ago, when one of these gongs was confiscated and auctioned, it was bought in for $2,500 United States currency. The proceeds from the sale of tobacco are saved for many years in order to buy a gong.

The Dusuns are short, sturdy, cheerful, not over-clean people, but exceptionally

ONE OF THE PEAKS OVERLOOKING LOW'S ABYSS

honest. They are, however, too shrewd and argumentative in bargaining. They were also most reliable and well-disciplined carriers, and once they get to know you and find out that you stand for no nonsense, everything goes well.

The Dusun women are small and well built and would be really quite pretty if they did not chew betel-nut, which blackens their teeth. The color of their skin is like that of a white person with a good sun tan, and their black hair is brushed smoothly back from their foreheads, ending in a topknot enclosed in a hairnet. Their dress, a long dark blue skirt almost reaching to their ankles, is held up by a series of brass rings or belts of five-cent pieces, which sometimes weigh in the neighborhood of ten pounds. A young girl or newly married woman will wear a piece of cloth over her breasts, held in place by hoops of lacquered rattan, leaving the whole back bare. Dusun women who have had a child usually wear nothing but the skirt. By contrast, the men are less picturesque, either wearing nothing but a loin cloth or an odd assortment of European clothes and a turban.

On the evening of the third day of our stay at Lumu Lumu the men returned from the mountain, saying that by working hard they had managed to complete the house. A few of them also brought one ground shrew, a tupaia and a spiny rat, all of which were in various degrees of decomposition, but knowing they were indigenous to the mountain and not knowing when I might get another, I skinned and made them up. It was at this point that I learned that my skinner had such an aversion to rats, verging on real fear, that for the rest of the trip I was to make up anything that had a ratty-looking tail.

The following morning we packed up for the last leg of the trip. Some of the loads being too light and learning that there was no bamboo at Lumu Lumu, I added lengths of this valuable material to the lightest loads but not without a great deal of arguing.

At Tinompok we branched off on to a very narrow and newly cut trail leading to the left at right angles to the main path. Three hours along this trail, which my porter had cut, brought us to our camp site. In spite of the steep ascent and the cold and dampness of the early morning, I was in high spirits.

The forest was tall, thick, very quiet and gloomy. Slippery logs and matted roots impeded our progress and a heavy mist clung to the very ground. There was hardly a tree or rock that wasn't covered with moss, and in certain places it formed a soft and squishy carpet, perforated with numerous rodent holes and trails. It wasn't until later that I learned that "Lumu Lumu" in Dusun meant "Mossy Mossy." No more appropriate name could have been chosen. Moss was the one thing that was everywhere, and in that respect reminded me of my camp on the top of "Doi Angka," in Siam.

(To be concluded)

LITTLE-KNOWN FOSSILS

By Dr. CHARLES T. BERRY
THE JOHNS HOPKINS UNIVERSITY

EVERY one who has ever lived along the seacoast is familiar with the common five- or six-armed starfish which is found clinging to the sides and bottoms of rocks just below low tide. These animals usually form one of the treasures in a small boy's collection, if he has ever gone wading in the ocean. Besides being of interest to the layman, these animals are of great economic importance, for they feed upon oysters among other things and are the greatest pest with which the oysterman has to contend, oftentimes destroying his entire bed and thus his livlihood.

Along with these destructive animals there can be found under the same rocks—if one's eyes are sharp—small five-rayed, slender serpentine-like armed animals, which are the first cousins of the starfish. These are called by some people serpent or brittle stars, but to the scientists they are known as Ophiurans. These brittle stars are seldom seen by the average person, for they leave their hiding places, under the rocks, only at night to go in search of food. Their search does not lead them to destroy things of economic value, so consequently they never make the headlines.

Both types of these animals roam the seas by the thousands and have done so for countless centuries. The brittle stars are descended from the starfish, whose line goes far back into Cambrian time some 540,000,000 years ago, when life first appeared on the earth. Associated with these primitive starfish, but much more numerous, were animals like the well-known trilobites and shellfish similar to our present-day oysters and clams. If the average person were shown one of the early primitive starfish he would undoubtedly object to its being called such; for instead of its having long flexible arms and measuring several inches across, it was less than half an inch in diameter, with very short, rigid arms. Heavy thick plates covered it, so that it was encased in a coat of armor. Unlike the plates of many of the living forms these did not possess any spines. After this primitive starfish various stages have been found which show the evolution of the animal. This evolutional trend is best illustrated by the arms, which became more and more flexible. This was accomplished by the dividing up of the heavy plates, thus decreasing their size; new plates were added, while others were undoubtedly reabsorbed. Thus with more and smaller plates the body and arms became more flexible, the latter lengthening until the present type of animal appeared.

The history of these animals as one traces it through the past is very interesting, for apparently they did not evolve gradually from a very few types into many different kinds until their present great number were reached. Instead, very few appeared at first here and there, and then as time went on they slowly increased. Suddenly conditions in the sea changed and the starfish found themselves in an unsatisfactory environment which forced many of them out of existence, leaving only the more sturdy ones to carry on the line. Again at another period (Fig. 1) prosperity would return and their population would increase rapidly only to decrease in the following period. The starfish reached their maximum extent, geologically

FIG. 1. DEVONIAN STARFISH. ×1.

speaking, during the Cretaceous period, when about sixty-five different types swarmed the seas.

During this time they had such companions as large turtles and fishes and serpent-like reptiles, which inhabited the seas together with many of present-day oysters and clams. Could the starfish have looked upon the land he might have watched the decline of the dinosaurs, and seen the forefathers of our mammals just starting to occupy the world, and he could have been a spectator as well at the formation of the early Rocky Mountains. With the close of this era conditions changed to such an extent that the starfish were almost completely destroyed, fewer surviving then than at any previous decline in their history. The few types which survived the Cretaceous continued to dwindle until at the close of our recent Ice Age there were only six types in our seas. With the melting of the ice in the northern hemisphere the oceans apparently changed to the liking of the starfish, for to-day they are found scattered throughout the world, there being something like 750 different types.

FIG. 2. JURASSIC BRITTLE-STAR. ×1.

While the starfish race was still young, at the close of the Cambrian time, a certain group of them became modified, forming the class known to scientists as the Auluroids. These animals did not differ a great deal from their cousins, the true starfish, in looks, but certain structural changes took place so that this type developed an entirely new line with new and different habits. The Auluroids lived for a span of some 225,000,000 years, dying out during the Carboniferous Age at the time when great beds of coal were being formed. Apparently the structural change which they evolved from the true starfish proved unsuccessful so that they could not combat certain changes in their habitat. Before they died out they gave rise to a new line which survived from that time on and is found living in our present seas. These are the brittle-stars. As is true to-day the brittle-stars were never as abundant in the seas of the past as were the true starfish. At their greatest extent, which was towards the close of Jurassic time (Fig. 2), there were only

23 kinds. These brittle-stars were represented by a very few at the close of our Ice Age. This is also the case with the starfish, but unlike them the brittle-stars never passed through so many rises or declines in their life's history.

We are able to trace all this history through the centuries by the fossil remains which have carefully been collected by the paleontologist. These remains, especially the earlier ones, consist of either the casts of the bodies or the actual petrified bodies themselves. It is only in the deposits, which were once soft and now have been turned to hard stone, that such remains are preserved. The skeletons of these animals do not lend themselves to preservation, for they have no solid outer shield like an oyster or snail nor do they have an internal skeleton of bones such as the vertebrates possess. Instead the body is composed of thousands of small calcareous plates held together by either a thin skin or by muscles. Thus it is necessary for the bodies to be covered quickly after death by some fine material in order to have them preserved intact. Otherwise they break apart and the plates are scattered over the ocean floor.

From the time of the fall of the starfish and brittle-stars during the Cretaceous age the type of deposits laid down were composed of such things as sands and clays, which have in general never become lithified. And also to make things more unsuitable for preservation of delicate objects, these deposits were quite often of a coarse texture. The total result was that such things as starfishes and brittle-stars are seldom preserved in their entirety in these deposits. However, the small calcareous plates which go to make up their bodies are often preserved and through them—with plenty of patience and care—the original animal can be reconstructed.

The history of the work on fossil brittle-stars is very interesting, even though brief. It was not until 1804 that Blumenback recognized the first fossil brittle-star as such, even though living Ophiurans had been described as early as 1733 by Linck, who thought their arms looked like the tails of lizards and named them accordingly. Fossils were not new to the scientists of the eighteen hundreds, for their recognition goes back to the days of Leonardo da Vinci. From 1804 until the end of the nineteenth century these animals occupied the minds of many geologists, who continuously discovered and described many new kinds. However, with the opening of the twentieth century the scientists' attention was drawn away from them

FIG. 3. PLATES FROM TERTIARY BRITTLE-STAR. ×4.

into other fields, so that since then practically no work has been done in this field.

In 1930 the present author opened up a new method of studying these little-known fossils. In that year, while searching through some of the unconsolidated Miocene sediments from Maryland, he discovered numerous small curiously shaped calcareous plates (Fig. 3), which later proved to be those which made up the skeletons of the brittle-stars. Not until that time had the plates been recognized for what they were, and it was generally thought that such sediments did not contain the remains of

these animals. Since then the author has continuously shown that these small animals are more numerous in the Tertiary deposits than anybody supposed and that not only their individual plates, but often the entire animal is preserved in snail shells, where apparently they had gone to hide during the day and had become entombed by sands and muds which covered the shell. All these can be found if only enough care is taken in searching for them.

The similarity of the fossil starfish to the living ones, which often advance in great numbers on an oyster bed, is shown by a find in some Devonian deposits. There is an area of about 200 square feet of muddy sandstone in New York State which contains upwards of 400 individual starfish. All these are of the same kind, and associated with them are a great number of fossil clams. The explanation is that these starfishes were in the midst of a meal when a great deal of sand suddenly covered them and in due time they became fossils. Other deposits such as this are known but none where so many individuals were concerned.

Have you ever watched a living starfish walk or had it move across your hand? If so, you have seen the innumerable small feet. These small feet have cups on their ends and are controlled by a water system within the animal. If he wants to fasten these feet to an object he withdraws the water from them forming a vacuum cup at their extremities which will hold firmly to any rock or shell. When he wants to let go, all he does is to pump the water back into the feet and the vacuum cups are turned inside out, thus releasing the hold. It is by this method of deflation and inflation of his tube feet that he can move along or cling to any object. This type of locomotion sharply separates the starfish from their living cousins, the brittle-stars, which do not have such tiny feet. Instead they move by pulling themselves ahead by the ends of their arms. This same difference in walking existed hundreds of years ago. However, in those early days the brittle-stars and the starfishes could not move their arms about easily, because their structure made them very stiff. This is especially true of the brittle-stars, for as time has passed their arms have become more and more flexible, as is shown by the placement of certain teeth on some of their tiny plates.

In the starfish there is a broad groove on the under side of each arm which is literally full of these tiny feet. Compare this with the under side of the arm of a brittle-star, and one does not see such feet. Instead if he looks carefully he will see innumerable pairs of small holes covered by very minute scales or plates. Sometimes through these openings will protrude what looks like a foot, but it is not. Long ago when the Auluroids separated from the starfishes and then the brittle-stars branched from them, there were radical changes produced in the skeletons of these animals, and with these changes many of the organs of the body changed in both position and function. The broad groove on the under side of the starfish became narrower until in the brittle-stars it was arched over by plates. With this arching over the feet were restricted to tiny openings and lost their function as feet and took on another function, that of respiration. The brittle-stars can draw in these breathing organs at will, closing the openings with the tiny cover plates if conditions warrant such action.

The seas were extremely devoid of different kinds of brittle-stars as well as the true starfishes during later geologic time—that is from the Cretaceous period until the close of the great Ice Age. In the opening period—the Eocene—there were two types of brittle-stars which inhabited European waters, for they are represented by fossil remains in Enland and Belgium. Another type occu-

pied seas of the same age in the western hemisphere, for their remains have been found in New Jersey. In the next period—the Oligocene—there is a single representative of these animals and that one comes from Mississippi, none having been found in other parts of the world. The Miocene seas apparently contained more of such animals, for North America is credited with three types and Australia and Poland with one each. Of those from North America one came from California and the other two from Maryland. Only one brittle-star of Pliocene age has been found, and that comes from Trinidad. Towards the close of the Ice Age of Pleistocene time the seas contained more brittle-stars than at any time since the Cretaceous, for nine different kinds have been found fossil in deposits of that age.

A parallel condition prevailed with regard to the true starfish, but they were in general two or three times more numerous during this time.

Why do we have so few fossils of both these animals during this period of time which embraces about 55,000,000 odd years? The answer is not in the least simple but very complex. One part of it is that they were not as numerous in the seas of that time as they were before or since. Another part is the fact that the sediments of these periods were not so conducive to preservation as the earlier ones were. And also—since they are poorly preserved—it requires more work on the geologists' part to make anything out of them. Hence they have been ignored for the sake of easier problems.

Upon tabulation of the entire number of both brittle-stars and starfish one finds that there are known only a little over 80 different kinds of fossil brittle-stars against some 1,400 living ones. A like contrast is shown when one considers the true starfishes, for these have been found only about 290 different fossil representatives of a family which has 750 different kinds swarming in the seas to-day. This shows conclusively how little is known of these animals from their fossil remains.

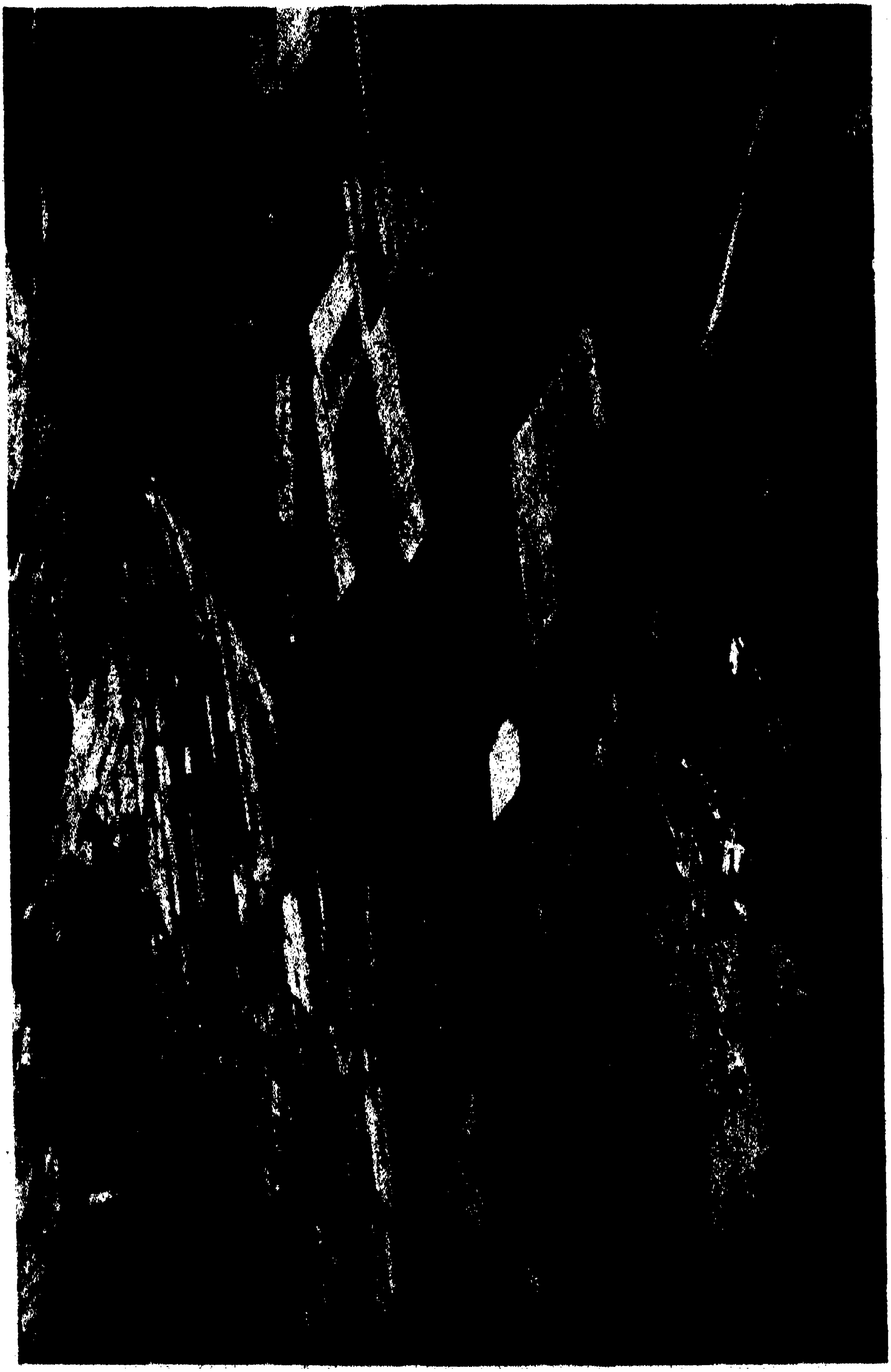


FIG. 1. MAGNETIC AND IONOSPHERIC OBSERVATORY, HUANCAYO, PERU
DEPARTMENT OF TERRESTRIAL MAGNETISM, CARNEGIE INSTITUTION OF WASHINGTON. COURTESY OF THE DIRECTOR.

THE IONOSPHERE

By Dr. E. O. HULBURT

UNITED STATES NAVAL RESEARCH LABORATORY, WASHINGTON, D. C.

THE region of the atmosphere at elevations greater than about sixty kilometers above sea level is heavily ionized and consequently is termed the "ionosphere." At high altitudes there are several hundred thousand molecules that have lost an electron and the same number of free electrons in each cubic centimeter. There are also ions in the atmosphere below sixty km; for example, there are on the average several hundred ions per cubic centimeter in the air at sea level and several thousand at twenty km above sea level.

The ionization of the atmosphere at high levels was discovered by means of radio waves in 1901; it was first measured by radio waves in 1924, and has been investigated since then by means of radio waves. From one point of view the investigation may be regarded as purely academic, and the ionosphere as just another geophysical phenomenon of interest to the geophysicist. From another point of view the ionosphere possesses a very practical aspect. It is essential to long distance radio communication, for all radio messages to distances greater than about 100 miles are by means of radio waves which have traveled from the transmitter to the ionosphere and have been reflected by the ionosphere down to the receiver. The waves get around the curve of the surface of the earth by successive reflections between the earth and the ionosphere. Thus an understanding

FIG. 2. MAGNETIC AND IONOSPHERIC OBSERVATORY, WATHEROO, WESTERN AUSTRALIA

DEPARTMENT OF TERRESTRIAL MAGNETISM, CARNEGIE INSTITUTION OF WASHINGTON. COURTESY OF THE DIRECTOR.

of the ionosphere, its storms and calms, its variations with day, night, latitude, season and sunspots, is of fundamental importance to the successful maintenance of long-distance radio circuits.

An ionosphere station for routine recording of ionospheric measurements is relatively elaborate and expensive, for it requires complicated sensitive electrical apparatus and trained operators. Since the ionosphere surrounds the earth, a number of widely distributed stations are necessary for a complete and continuous survey. The first established station was that of the United States National Bureau of Standards at Washington, D. C., latitude 39° north, which commenced operation in 1930. It was the pioneer in the development of automatic recording equipment, and its hourly records by means of the equipment have been continuous since May, 1933.

Ionosphere equipment was installed several years ago by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington in its stations at Huancayo, Peru, latitude 12° south, and at Watheroo, Western Australia, latitude 30° south. Automatic recorders were recently installed in these two stations and the results are beginning to be reported. More or less complete data during various years, for the most part since 1933, have been obtained by stations at Tromsö, Norway, 70° north, at Slough, England, 52° north, at Tokio, Japan, 36° north, and at Central China College, Wuchang, 30° north. The last station ceased operation in June, 1938, due to war conditions. Ionospheric measurements for short periods of about a year or less have been carried out at various places—for example, at Deal, New Jersey, 40° north, in 1933 and 1934, and at North-east Land, 80° north, in 1935 and 1936, and at several north polar latitude stations during the International Polar Year 1932–1933.

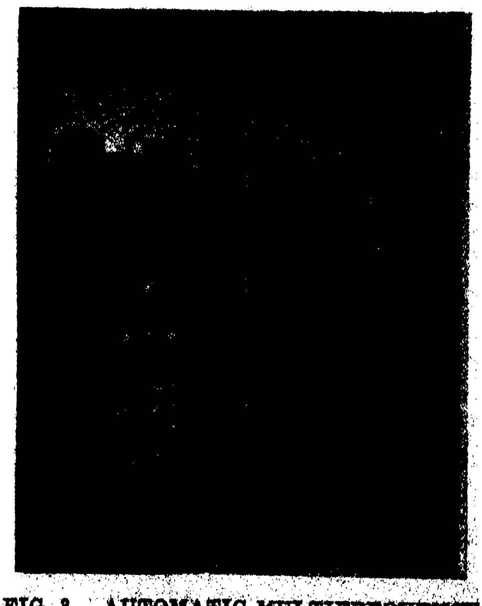


FIG. 3. AUTOMATIC MULTIFREQUENCY RECORDER

IONOSPHERE STATION, MEADOWS, MARYLAND, UNITED STATES NATIONAL BUREAU OF STANDARDS, WASHINGTON. COURTESY OF THE DIRECTOR.

At the present time there are seven ionosphere stations functioning, or preparing to function, with complete equipment, namely; Tromsö, 70° north; Slough, 52° north; Washington, 39° north; Tokio, 36° north; Huancayo, 12° south; Watheroo, 30° south, and Sydney, Australia, 34° south. The northern latitudes are adequately covered except for a considerable lacuna in the lower latitudes between 36° north and 12° south. Consideration is being given to the establishment of a station at a latitude around 15° north in India under the direction of Professor M. N. Saha. In south latitudes there are three stations. It appears that at least one more station south of the equator would be desirable, as, for example, a station in latitude 40° south, in New Zealand or South America. A station in high latitudes around 80° would be of interest, but due to geographical difficulties the establishment of such a station does not appear probable.

The Washington ionosphere station of the United States National Bureau of

Standards publishes monthly the average ionospheric data of each month. It also distributes a weekly bulletin giving ionosphere measurements of the week and data of ionospheric storms and disturbances, together with radio information derived from the ionospheric data such as the optimum radio frequencies for communication to various distances at various hours of the day. The other stations publish their data quarterly or more or less intermittently. The ionosphere station is the radio weather observatory and its data are the weather conditions for radio traffic.

An ionosphere measurement consists of a series of experiments which require about five minutes for their performance. The measurement is based on the radio echo method developed by Dr. G. Breit and Dr. M. A. Tuve in their pioneer exploration of the ionosphere in 1925 at the Department of Terrestrial Magnetism of the Carnegie Institution. A radio transmitter is arranged to send out a short pulse, about 1/1000 second in length, of radio waves of a desired radio frequency. The pulse is recorded by a nearby receiver, either in the same room or building with the transmitter or within a distance of a few miles. A single pulse from the transmitter usually produces two or more pulses in the receiver, one of which is due to waves that have passed directly to the receiver, the "ground" wave. The other pulses are due to waves that have traveled up to the ionosphere and have been there reflected back to the earth again; they are the "sky" waves, and the pulses are their echoes. One half of the time difference between the ground pulse and the echo multiplied by the velocity of light in vacuum gives the optically equivalent height or the "virtual" height, of the ionized region where reflection occurred.

The radio frequency of the transmitted pulse is then increased step by step and the echo observation is repeated at each

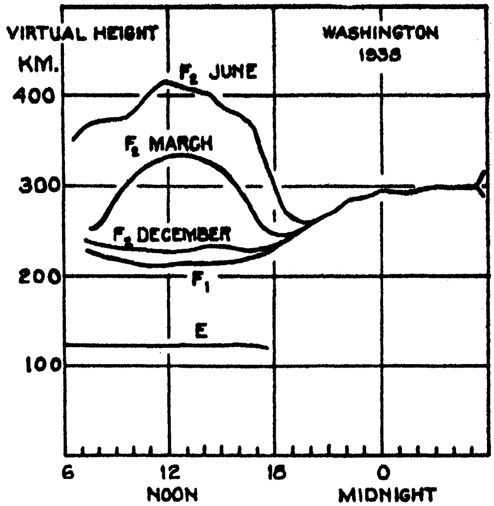


FIG. 4. MONTHLY AVERAGE VIRTUAL HEIGHTS OF IONOSPHERIC REGIONS, 1938, WASHINGTON.

step. When the radio frequency becomes high enough the waves penetrate the region of ionization and are no longer reflected from it. From the observed frequency at which penetration begins the density of ionization, *n*, of the region may be calculated. The quantity, *n*, is usually the number of electrons per cubic centimeter on the assumption that the ionization is composed of an equal number of negative electrons and positive ions. If there is another region of ionization of greater density situated above the region which has been penetrated, echoes are reflected from it and continue to be reflected until with increasing frequency penetration again occurs. Finally the frequency becomes so high that all regions of ionization are penetrated and there are no more echoes. In this way the virtual heights and densities of all the regions of ionization are mapped out.

The radio frequencies of the transmitted pulses are usually included in the range from 500 to 16,000 kilocycles per second. The received pulses are registered on automatic recording equipment. Several minutes are required for the transmitter to sweep through the frequency range and for the echoes to be

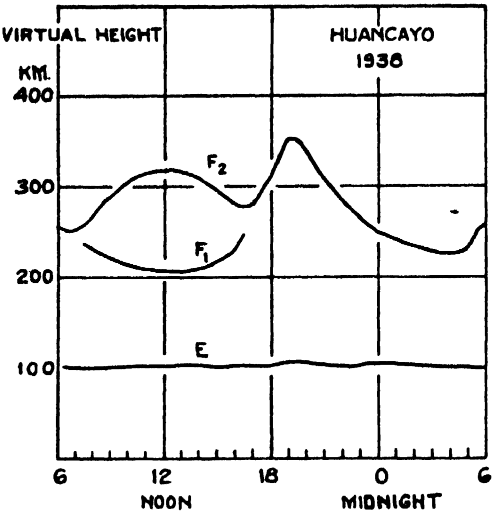


FIG. 5. MONTHLY AVERAGE VIRTUAL HEIGHTS OF IONOSPHERIC REGIONS, 1938, HUANCAYO.

recorded. In the most recent equipment four or more measurements are made each hour. It has been found desirable for each station to average the values of the virtual heights and electron densities for each hour of the day throughout the days of the month. In this way daily and seasonal variations are revealed and effects of sudden and erratic changes are smoothed over.

Although the transmitted pulses sweep continually through the broadcast frequency range and various commercial high frequency bands, the pulses are too short to be heard or to cause disturbance in the ordinary radio receivers. The ionosphere echo receivers, on the other hand, are troubled by high-power radio transmitters and must be located so as to avoid interference from them.

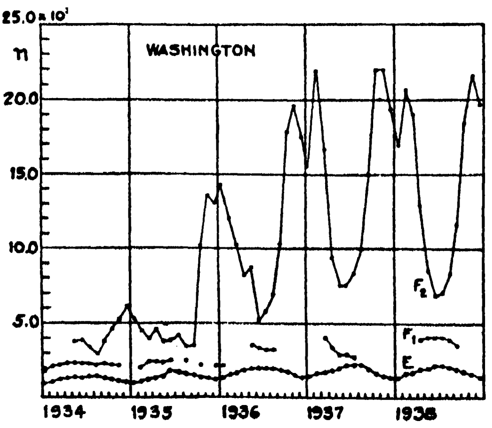


FIG. 6. MONTHLY AVERAGE NOON VALUES OF ELECTRON DENSITY N OF IONOSPHERIC REGIONS, WASHINGTON.

It is found that during the day there are three main regions of ionization in the ionosphere and two at night. These are designated by E, F_1 and F_2 for day and by E and F for night, the daytime regions F_1 and F_2 coalescing to form the night F region. In Figs. 4 and 5 are given the virtual heights of the ionospheric regions in 1938 at Washington for various seasons and at Huancayo averaged over the year. There was little change in the virtual heights with the season at Huancayo; this station, latitude 12° south, is near the equator and no great seasonal effects would be expected. The virtual heights at Northeast Land, latitude 80° north, were similar to those at Washington, and likewise for those at Watheroo but with a six-month shift of phase.

The true height of a region above sea level is always less than the virtual height and may be estimated from the virtual height, but not always very exactly. For E, F_1 and F_2 the true height is rarely more than 40 km below the virtual height, but for F_2 the difference may be as much as 100 km. From the data of Washington, Huancayo and other stations it appears that the true height of E above sea level is between 100 and 130 km and remains within these limits for day, night, latitude and season. The region F_1 is at about 200 km above sea level and its altitude varies less than about 40 km with the latitude and season. The night F region is at about 250 km above sea level, the variation with latitude and season being less than about 50 km. The virtual height of F_2 exhibits pronounced changes with the time of day, the latitude and with the season in temperate latitudes. It increases

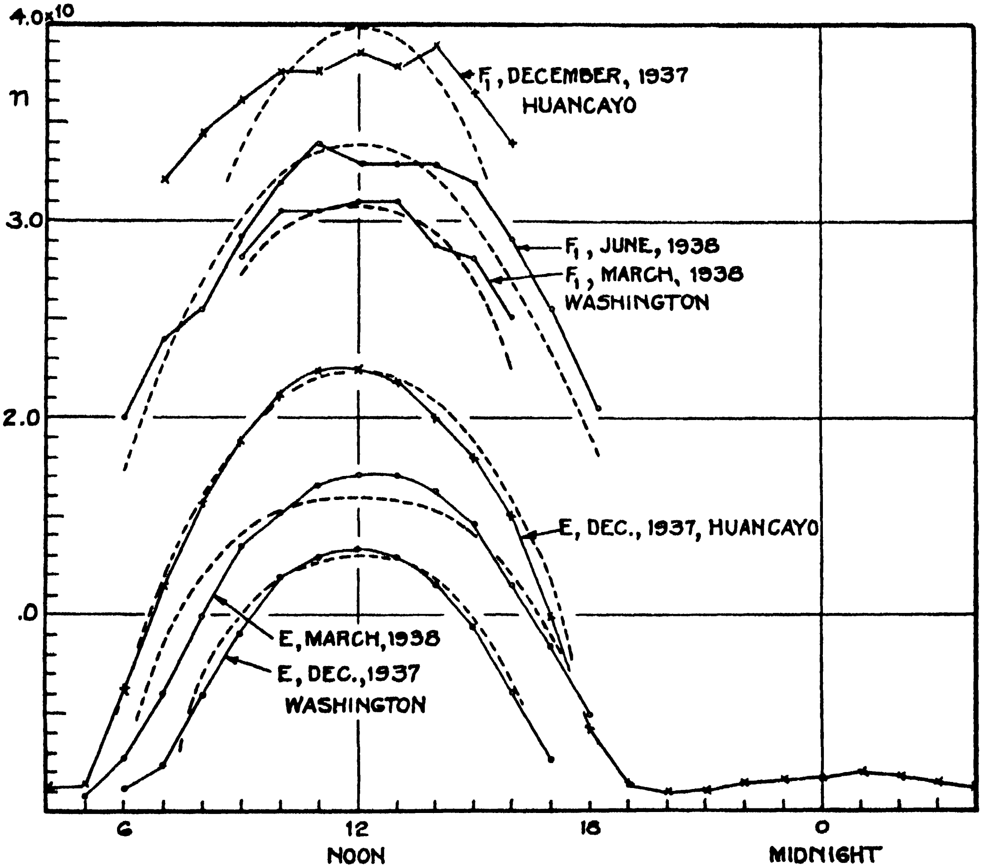


FIG. 7. MONTHLY AVERAGE VALUES OF ELECTRON DENSITY N OF E AND F_1 FOR VARIOUS SEASONS AT WASHINGTON AND HUANCAYO. DOTTED CURVES CALCULATED FROM THEORY.

to a maximum value at about noon at all latitudes north and south, the noon values at Washington being about 400 and 240 km for summer and winter, respectively; the virtual height at Huancayo the year around being similar to that for summer conditions at Washington. The true height of F_2 probably follows the virtual height changes but with less amplitude. There were no important changes in the virtual heights with increasing sunspots from 1933 to 1938.

The electronic density n is greater for F_2 than for F_1 and greater for F_1 than for E. This is natural, because a region of ionization lying above a lower region can only be observed in the case that it is of greater density of ionization; if it were of less density it would be shielded by the underlying region from the terrestrial observer. The monthly average noon values of n for Washington for 1934 to 1938 are plotted in Fig. 6. The ionization density n of all regions increased during these years, which were a period of increasing sunspots. The yearly average sunspot numbers were 5.7, 8.7, 36.1, 79.7, 114.4 and 110.3, respectively, for 1933, 1934, 1935, 1936, 1937 and 1938; 1933 was the minimum and 1938 the maximum of the sunspot cycle. It appears that n of F_2 experienced a greater augmentation with sunspots than n of E or F_1.

Fig. 6 also brings out the fact that F_1 usually appears only when the noon zenith angle of the sun is less than about

40°. The region, F_1 appears mainly during the summer months at Washington, and is usually in evidence at Huancayo during the daylight hours at all seasons. On the whole F_1 is of minor interest, appearing to be a sort of protuberance on or near the lower side of F_2. It plays little part in radio wave propagation, for the reflection of radio waves usually occurs from F at night, from E during the day in tropical and summer temperate latitudes, and from F_2 during the day in winter temperate and polar latitudes.

It is not known what types of ions constitute the various ionospheric regions, except that electrons form a part of all regions. Some thecretical calculations suggest that F_2 contains atomic oxygen and nitrogen ions, F_1 atomic or molecular nitrogen ions and E molecular oxygen ions. To investigate the question by direct experiment on the ionosphere promises to be difficult, and it seems probable that for some time any answers will come from a combination of laboratory experiment and theoretical conjecture.

The diurnal variation n of E and of F_1, illustrated in Fig. 7, is fairly regular and reaches a maximum value at about noon; in general for these regions n increases with decreasing solar zenith angle. The diurnal and seasonal variation in n of F_2 are complex, some of the data being in the curves of Fig. 8. At Huancayo, and at Washington in summer, F_2 has two maxima, a ragged and erratic maximum near noon and a higher, broader maximum in the afternoon near sunset. In winter at Washington n of F_2 has only a single maximum around noon which is greater than the summer day maxima. The value of n of F_2 is at all times more variable than the altitude of E or F_1, its value at any particular hour sometimes varying as much as forty per cent. from day to day. During the night n of F decreases, having, however, occasional temporary increases of as much as 50 per cent. During nights in midwinter at Washington a minor recrudescence of F ionization in the small hours of the night is the rule rather than the exception.

The variations of n with latitude for E and F_2 are shown by the average noon values plotted in Figs. 9 and 10. In Fig. 9 the data of Northeast Land, Tromsö

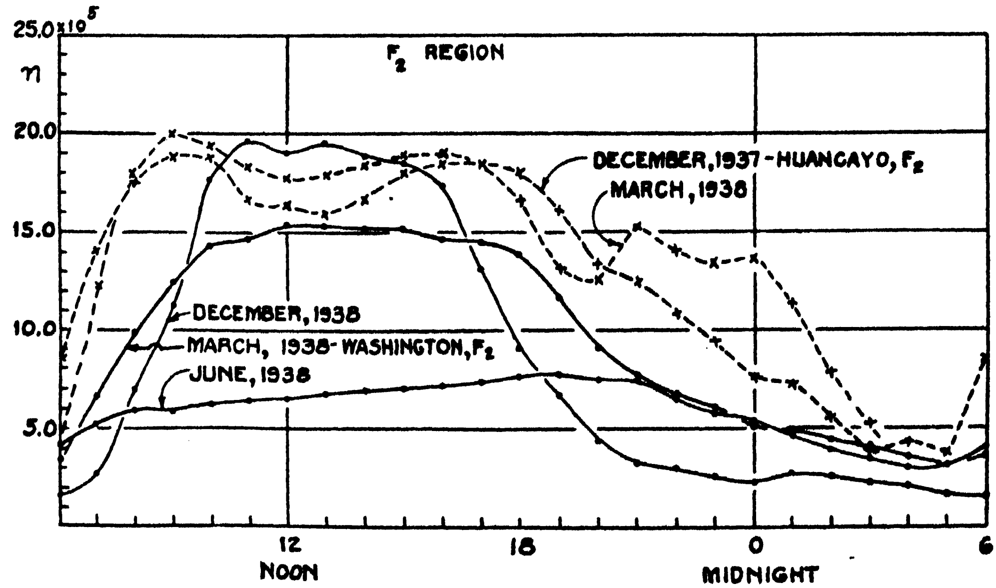


FIG. 8. MONTHLY AVERAGE VALUES OF ELECTRON DENSITY N OF F_2 FOR VARIOUS SEASONS AT WASHINGTON AND HUANCAYO.

and Washington were for 1936, and of Huancayo for 1938; there were available no data for 1938 at Northeast Land and at Tromsö, and for 1936 at Huancayo. It is justifiable to compare the data for the two different years at the various stations, since the Washington E values were much the same in 1936 and 1938. The F_2 values of Fig. 10 comprise practically all available noon F_2 data. Again, it appears from Figs. 9 and 10 that n increases with decreasing solar zenith angle.

We may summarize the foregoing facts and describe the main world-wide features of the ionosphere known at the present time. The E and F_1 regions are fairly simple, lying at about 100 and 200 km levels, respectively. Since density of ionization of each is a maximum directly under the sun, the E region fades to low values during the night and the F_1 region is swallowed up on the twilight circle by the descending F_2 region. The F_2 region is more complicated. It swells out toward the sun, spreading out through altitudes of perhaps 220 to 400 km, and contracts back to a 250 km level in the twilight zone. Its density of ionization is always greater and more variable than those of the E and F_1 regions. In tropical latitudes its density of ionization has two maxima, an irregular one around 10 A.M. and a larger, smoother one near sunset; in temperate latitudes there is a single maximum in winter and in summer there are two maxima similar to those in the tropics, except that often the morning maximum is ill defined. During the night the F ionization diminishes at all latitudes with irregular ups and downs.

Since the ionization of the ionospheric regions increases during the day and diminishes at night, there is no difficulty in believing that the most important cause of the ionization is radiations from the sun, but not the light which reaches the terrestrial observer. It is believed that the ionization is due to very short wave radiations which are completely absorbed

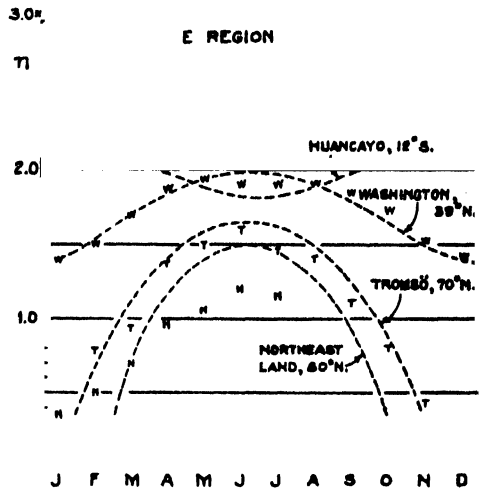


FIG. 9. MONTHLY AVERAGE NOON VALUES OF N OF E SHOWN BY INITIAL LETTER OF STATION; DATA OF NORTHEAST LAND, TROMSÖ AND WASHINGTON FOR 1936 AND OF HUANCAYO FOR 1938. DOTTED CURVES CALCULATED FROM THEORY.

in the high levels of the atmosphere, for in laboratory experiments such radiations do ionize gases. The view is taken that the observed ionization is the result of two opposing factors one being a rate of production of ionization by the action of solar ultra-violet light in splitting neutral air molecules and atoms into negative electrons and positive ions, and the other being a rate of loss of the ionization by recombination of the electrons and ions to form neutral air particles. The density of ionization which exists at any place and time depends on the values of the two rates. The simplifying assumptions are made that the rates of ion production and recombination are fairly rapid, that winds and movements of the high atmosphere are not great enough to modify appreciably the distribution of the ionization and that the character of the high atmosphere, such as pressure, temperature and constitution, is constant over the earth.

In Fig. 7 the dotted curves were calculated under the assumption that the rate of ionization depends only on the zenith angle of the sun, with the noon value n_0 adjusted for each curve to give the best

fit with the measured values. It is seen that the theoretical values agree well with the changes in n of E during the daylight hours; in the case of n of F_1 the agreement is not close. In Fig. 9 the dotted curves were calculated with $n_0 = 2 \times 10^5$ for all stations; it appears that the changes of n of E at noon with the season at any station are in fair accord with the simplified theory of a quiet atmosphere. Fig. 9 also brings out the fact that for any season n of E at noon falls off more rapidly with latitude than would be expected from theory; the observed values of n are below these calculated by about 0, 10, 20 and 30 per cent. at latitudes 0°, 40°, 70° and 80°, respectively. The suggestion has been made that the E region of the atmosphere may not be exactly of the same character at all latitudes, but that, for example, the temperature or molecular dissociation may vary from the equator to the poles; and that this variation may cause a change with latitude in the rate of recombination in such a way as to account for the moderate discrepancy between theory and observation.

In the case of the diurnal variation of F_2, given in Fig. 8, there is no question but that the simple theory of a quiet atmosphere misses the facts by a wide margin, for theory yields a single maximum in n at noon, whereas n has a double maximum at Washington in the summer and at Huancayo the year round.

To explain this phenomenon, it is assumed that in levels above about 250 km there is an expansion of the atmosphere underneath the sun, due to the effects of sunlight in heating the high atmosphere and in dissociating oxygen and nitrogen molecules into atoms. The expansion spreads out the atmosphere in the vertical direction and reduces the electron density in the F_2 region. Thus in the tropics n begins to increase in the morning due to the increasing light intensity, but soon the expansion in the air reduces the number n in a unit volume in spite of an increase in the total number of electrons in a vertical column of the atmosphere. Hence n passes through a maximum in the morning. In the afternoon the march of events is reversed; the total ionization decreases with the lowering sun, but the contraction of the atmosphere is sufficiently rapid to effect an increase in n of F_2 for a time and to cause it to pass through a second maximum in the afternoon.

There is another effect which is a consequence of the expansion hypothesis. Due to the expansion of the F_2 atmosphere, winds in levels above 250 km blow away in all directions from the region directly beneath the sun. Westward from the sub-solar point, and hence in the morning hemisphere, the stream of F_2 air moves against the rotation of the earth, is checked and becomes turbulent as the white-capping waves in a tide-rip, whereas eastward, and hence in the afternoon hemisphere, the stream moves with the direction of rotation of the earth and remains smooth and undisturbed. The effects are in accordance with the observations of F_2 which at the equator record a greatly disturbed and erratic layer in the morning and a less disturbed ionization in the afternoon, with a broad maximum at 6 or 8 P.M.

The expansion and wind theory provides a qualitative explanation of the seasonal variation of the noon values of F_2 ionization. In Fig. 10 are plotted practically all reported monthly average noon measurements of n of F_2. From the curves it is seen that in the northern hemisphere n has a midwinter minimum, attributed to winter weakness of ionizing light, and a deeper midsummer minimum, attributed to summertime expansion and winds. In southern latitudes the march of noon n of F_2 should be the reverse, or displaced six months in phase, from what it is in northern latitudes. In so far as data at Washington, 39° north, and at Watheroo, 30° south, may be compared, this is roughly true in that the curves

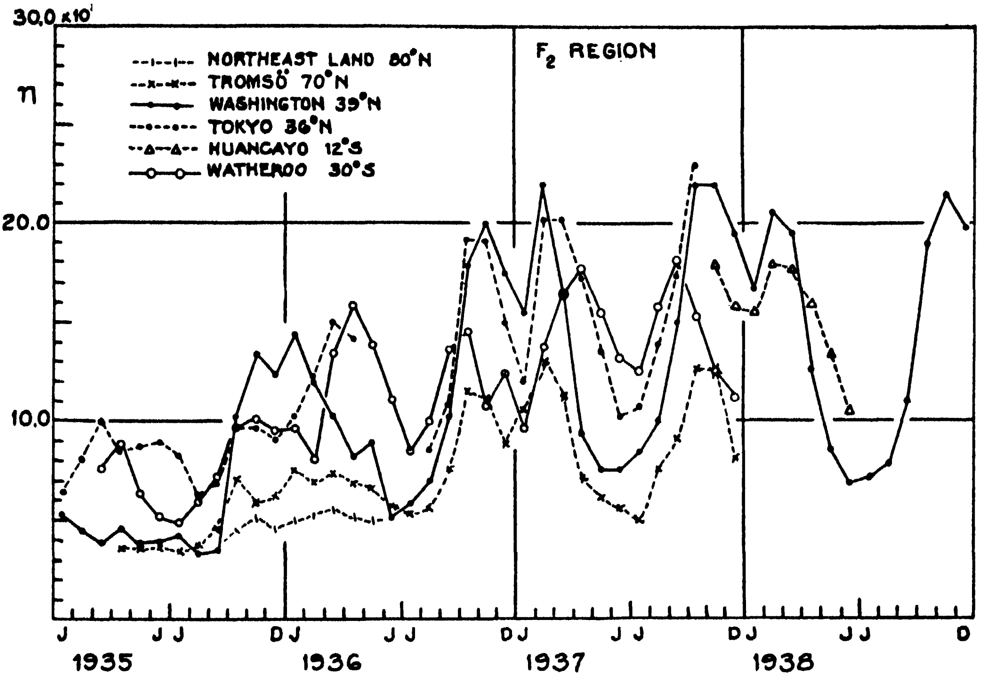


FIG. 10. MONTHLY AVERAGE NOON VALUES OF N OF F_2.

of these stations in Fig. 10 cross near equinox. The comparison should be made at two stations at equal latitudes north and south. Further data from southern latitudes would be desirable.

There are several ionospheric effects which are not explainable by a simple theory of ion production by solar radiation in a quiet atmosphere. It is often observed that pulses of radio frequencies above the penetrating frequencies of the normal *E* region suddenly begin to be echoed back from the *E* region, indicating the *E* ionization has suddenly become a better reflector or scatterer of the high frequency pulses. The phenomenon is known as "sporadic" *E;* it usually lasts only a short time, for a few minutes or an hour. Sporadic *E* echoes are local and do not occur simultaneously at stations a few hundred kilometers apart; they are infrequent near the equator, increase in frequency with the latitude, and in temperate latitudes occur both day and night. The sporadic *E* echoes are not correlated with other types of ionosphere irregularities or thunderstorms or other known phenomena. A reasonable suggestion has been made that the echoes arise from scattering by clouds or irregularities of ionization caused by winds. The optical analog is the white caps of the waves on a windy sea, which scatter much more light than is reflected by a calm water surface (hence they are white caps). If the suggestion is true, the area of ionic irregularities must often be considerable, several hundred square kilometers or more.

The ionization of both *E* and *F* regions, although in general decreasing during the night in accordance with the notion of recombination and no production of ions at night, is often observed to undergo nocturnal augmentation. Whether the enhancement is due to effects in the atmosphere, as scattering by ionic clouds due to winds ("white cap" theory), generation of ionization by collisions of excited or combining atoms ("spon-

taneous generation'' theory), night cooling of the region warmed during the day (''contraction'' theory), or by effects external to the atmosphere, as meteors (''interplanetary debris'' theory), stellar radiations (''cosmic radiation'' theory), or by some other effect (''angel'' theory), can not be said. There is no dearth of suggestion and no lack of difference of opinion.

An important type of ionospheric disturbance which occurs only on the illuminated half of the earth is that associated with radio ''fade-outs.'' Attention was first called to the phenomenon by Dr. J. H. Dellinger and much is now known about it as the result of investigations carried out by him and his colleagues of the Washington ionosphere station and by the staff of the Huancayo station. The fade-out is a sudden disappearance of radio signals for a few minutes, the complete process of fading out and reappearing occupying a time usually less than an hour. The strength of the radio signal falls to zero in usually less than a minute, the effect being simultaneous throughout the sunlit hemisphere of the earth and most intense directly under the sun. By means of cooperation with the Mt. Wilson solar observatory it was observed that radio fade-outs occurred at times when there were unusually bright hydrogen eruptions on the surface of the sun. Ionospheric observations showed that the fade-out was caused by a sudden increase of ionization at or slightly below the *E* level, which produced heavy absorption of the radio signals. Therefore the evidence is fairly complete that the ionization which occasions the fade-out is produced by a sharp burst of radiation from a hydrogen eruption on the surface of the sun which travels in straight lines from the sun to the earth with approximately the velocity of light. The radiation is in all probability ultra-violet light.

This is the first instance in which the cause of a definite unusual terrestrial circumstance has been traced, almost beyond doubt, to a definite unusual happening on the sun. The hydrogen eruption usually, but not always, occurred near an active sunspot group. The numbers of known ionospheric disturbances of the fade-out type were 17, 103 and 220 in 1935, 1936 and 1937, and thus increased rapidly with the increase of sunspots in these years.

In the foregoing paragraphs, the relation of ionospheric phenomena to radio wave propagation has barely been touched upon, while its relation to terrestrial magnetism has not been mentioned at all. An adequate discussion of these important topics is too long to be included here.

MAN'S CREATIVE YEARS IN MUSIC

By Professors HARVEY C. LEHMAN and DeFOREST W. INGERHAM

DEPARTMENT OF PSYCHOLOGY AND DEPARTMENT OF MUSIC, OHIO UNIVERSITY

In what years is the best work done? What are the chronological ages at which men are most likely to compose delightful and immortal music? Perusal of the literature discloses almost every conceivable answer to the foregoing questions. For example, Phelps states that musical composition appears at early ages,[1] Dorland believes, on the other hand, that the best music is composed late in life.[2] Still another writer asserts that there are two types of geniuses, one of which matures early, the other late,[3] and Pitkin assures us that "Musical genius, high and low alike, flowers early and continues in bloom throughout life."[4] From these mutually contradictory statements what is one to conclude? What are the facts?

It is obvious of course that unsupported assertions prove nothing. To the critical student it is equally obvious that the method used by Dorland, that of simply naming a large number of men of a given chronological age who have composed noteworthy musical selections is of questionable validity. Before accepting conclusions that are based upon what are alleged to be "illustrative cases," the critical student will insist upon knowing whether the illustrations are really typical or whether they are very exceptional. By the selection of some exceptional cases and the omission of others, it is possible to make an apparently strong case for almost any preconception whatsoever. But for impartial study of the creative years an adequate method is needed—a method which takes account of both exceptional and typical instances. Accurate conclusions regarding the chronological ages at which men have most frequently composed various types of superior music will involve therefore: (1) Assembling a reasonably large random sampling of various types of superior music, and (2) determining for the composers of each type of music the average number of compositions per chronological age level.

In previous articles[5] the fact has been stressed that when age differences in creativity are being studied proper allowance should be made for the fact that individuals do not always live to a ripe old age. Some die early; others die during middle age. Therefore, since the representatives of the younger age groups are always more numerous than the representatives of the older age groups, the younger age groups might conceivably accomplish more merely because of their greater numerical strength. Computation of the average number of achievements of each age group eliminates this difficulty.

Several additional facts should be considered. It obviously is not possible to study the entire life work of persons who are still living and achieving. There is no way of knowing what such individuals may accomplish during their later years. The present study includes for the most part, therefore, data for deceased com-

[1] W. L. Phelps, *The Reader's Digest*, 24: 79–81, 1924.

[2] W. A. N. Dorland, "The Age of Mental Virility," The Century Co., New York. Pp. vii + 229, 1908.

[3] H. Harvey-Day, *Magazine Digest*, 11: 85–86, 1935.

[4] W. B. Pitkin, "The Psychology of Achievement," Simon and Schuster, New York. Pp. xi + 502, 1931. (See p. 205.)

[5] (a) H. C. Lehman, THE SCIENTIFIC MONTHLY, 43: 151–162, 1936; (b) H. C. Lehman, THE SCIENTIFIC MONTHLY, 45: 65–75, 1937.

posers.[6] For these the record is complete, and future research will probably change it only slightly, if at all.

Grand Opera

Data for the production of grand opera will first be submitted. In his "Cyclopedia of Music and Musicians,"[7] W. S. Pratt presents dates of first publication[8] for more than 2,000 grand operas that were composed by more than 500 individuals. With the foregoing information, together with the birth and the death dates of the composers, it has been possible to obtain the average number of operas that were produced at each successive chronological age level.

In Fig. 1 the solid line presents the chronological ages of 134 Italian composers at the time 650 of their grand operas were either first produced or first published. In studying the solid line in Fig. 1 it should be remembered that this curve presents the average number of operas per chronological age level.

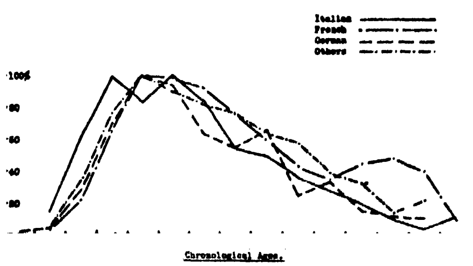


FIG. 1. AVERAGE NUMBER OF GRAND OPERAS THAT WERE FIRST PRODUCED DURING EACH FIVE-YEAR INTERVAL OF THE COMPOSERS' LIVES. THIS GRAPH IS BASED ON OPERAS THAT WERE WRITTEN BY ITALIAN, FRENCH, GERMAN, AND "OTHER" NATIONALS.

Proper allowance is thus made for the larger number of youthful composers.

For example, for the 134 Italian composers whose works are set forth in Fig. 1, it was found that 130 of them published 24 grand operas at age 35. This was slightly more than an average of .18 of an opera per individual. Of these 130 composers, 85 were alive at age 60. The 85 composers surviving at age 60 published only 6 operas, which was slightly more than .07 of an opera per living individual. In Fig. 1 the solid line is so drawn as to be only about a third as high at age 60 as at age 35, thereby indicating that the average number of grand operas was only about a third as great at age 60 as at age 35.[9]

If, regardless of the number of composers that remained alive, the men of age 60 had produced operas at the same average rate as did the men of age 35, the solid line in Fig. 1 would remain as high at age 60 as at age 35. However, the curve descends very markedly at the older age levels. Is this decrement due to loss of ability to compose grand opera? Or is it perhaps due to certain other factors which accompany advance in age?

[6] There will be two exceptions to this rule. These exceptions will be noted when they occur.

[7] W. S. Pratt, "The New Cyclopedia of Music and Musicians," The Macmillan Co., New York. Pp. vi + 967, 1924.

[8] Pratt states: ". . . where dates are given they are usually those of first performance or publication." Reference 7, p. 180.

[9] In constructing the graphs that accompany this article, the data for each of them were first reduced to a comparable basis by the following procedure: The peak of each statistical distribution was arbitrarily assigned a value of 100 per cent. and the other averages within the same statistical distribution were assigned proportionate percentage values. For example, in Fig. 1, the peak of the distribution for the Italian composers occurred at ages 35 to 39 inclusive. At this latter age interval the average number of grand operas per composer was .165. In the solid line of Fig. 1 the decimal .165 is plotted therefore as 100 per cent. At the age interval 65 to 69 inclusive, the average number of operas per composer was .035. This latter decimal fraction is equivalent to 21 per cent. of the maximum production (21 per cent. of .165) and in Fig. 1 the decimal .035 is plotted therefore as 21 per cent. The foregoing method of plotting should be borne in mind when studying the graphs.

A Comparison of Four National Groups

In Fig. 1 the solid line presents data for Italian composers only. The three remaining lines of Fig. 1 present data for French, German and "other" nationals. In general, these age-curves reveal striking similarity. As regards the production of grand opera, significant and consistent changes seem to occur with advance in chronological age regardless of nationality. In Fig. 1 it is apparent that: (1) All four of the curves rise somewhat more rapidly than they descend; (2) each curve remains at nearly its maximum height for a period of ten to fifteen years; and (3) the Italians appear to compose more operas at the younger age levels than do the composers from the other countries.[10] This latter finding will perhaps be most easily understood by those who have traveled in Italy and who have observed that in Italy even the small boys on the streets are likely to be heard whistling the airs of the well-known operas.

The Best-loved Grand Operas

Fig. 1 is based upon data that were available in Pratt's "Cyclopedia of Music and Musicians." Since Fig. 1 presents data for more than 2,000 operas, this figure does not yield definite information as to when the best-loved operas were produced. The production of the grand operas that are most preferred by music lovers is revealed in Fig. 2. The data that were employed for the construction of Fig. 2 were obtained from the ninth edition of "The Victor Book of the Opera."[11] This latter volume is the result of an attempt to select only those grand operas that possess lasting value and that opera-goers are most likely to hear.[12] In the preface of the foregoing book the editors make the following explanatory statement:

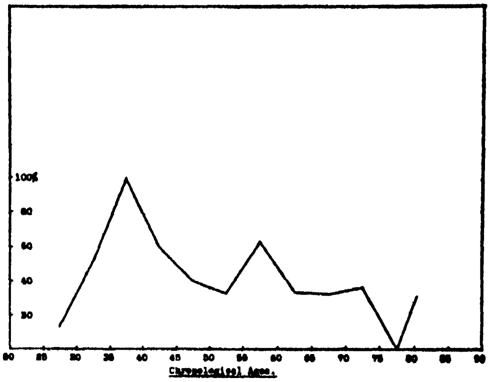


FIG. 2. AVERAGE NUMBER OF BEST-LOVED GRAND OPERAS THAT WERE FIRST PRODUCED DURING EACH FIVE-YEAR INTERVAL OF THE COMPOSERS' LIVES. THIS GRAPH IS BASED ON 82 OPERAS BY 38 COMPOSERS.

> It has been our aim to make the present edition of *The Victor Book of the Opera* as representative as possible by including all the Standard operas regularly played in the repertoire and the newer operas that seem to be of permanent interest.

If it be granted that the above-mentioned purpose has been attained by the compilers of "The Victor Book of the Opera," it seems evident that the grand operas that are most preferred by opera-goers have been composed most frequently by men of ages 35 to 39 inclusive.

Critical readers may wonder whether the shape of the curve in Fig. 2 is not perhaps due to the particular book that was employed for obtaining data. Might

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10 The method of plotting the curves might have given rise to an erroneous conclusion at this point but, as may be seen by study of Table II, no such error has occurred. Table II reveals clearly that, prior to age 30, the average number of operas per composer is definitely greater for the Italians than for any of the three other groups.

11 "The Victor Book of the Opera," RCA Manufacturing Co., Camden, New Jersey. Pp. 526, 1936.

12 In the construction of Fig. 2 data for a few living composers were included. However, their inclusion did not influence appreciably the shape of the age-curve. Perhaps it should be mentioned also that, although a few comic operas are listed in "The Victor Book of the Opera," the comic operas were excluded when data were assembled for the construction of Fig. 2.

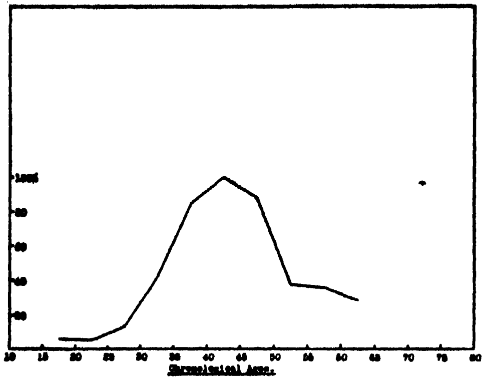


FIG. 3. AVERAGE NUMBER OF LIGHT OPERAS AND MUSICAL COMEDIES THAT WERE FIRST PRODUCED DURING EACH FIVE-YEAR INTERVAL OF THE COMPOSERS' LIVES. THIS GRAPH IS BASED ON 121 COMPOSITIONS BY 54 INDIVIDUALS.

not other books that list the noteworthy grand operas yield curves of quite different shape? The present writers sought an answer to the foregoing question by separate study of seven additional opera guides[13] (eight books in all) which purport to list the best-liked operas.

What was found when age-curves were drawn by using data obtained from these eight books? The eight age-curves were found to differ in no essential respect from the curve that is shown in Fig. 2. Each of the eight curves attained its maximum height and each curve exhibited a rather narrow peak at the age interval 35 to 39 inclusive.

Light Opera and Musical Comedy

Fig. 3 presents data for 121 light operas and musical comedies that were written by 54 individuals from six different countries.[14] Among the 54 composers are Germans, Frenchmen, Englishmen, Americans, Italians and one Russian. Perusal of the 121 titles will serve to convince any impartial reader that, collectively, these are very superior works of their particular kind. For these light operas and musical comedies the peak of the age-curve occurs at ages 40 to 44 inclusive, which is five years later than the peak for the production of favorite grand operas. (See Fig. 3.)

In Fig. 3 notice the rather narrow age-range during which the majority of the light operas were produced. As will appear later, for most types of musical composition that have been studied by the present writers, the most preferred works seem to have been composed during a somewhat narrower age-range than was the aggregate of the same type of composition.

Orchestral Music

Whereas, Figs. 1 to 3 inclusive are based upon the chronological ages of the composers at the time of first performance or first publication, Fig. 4 on the other hand reveals the ages of the composers *at the time of composition.* Thus, Fig. 4 presents composite age-curves that were constructed by the use of data obtained from: (1) Three source books[15] which list orchestral selections of lasting popularity, and (2) six source books[15,16]

[13] (a) G. Kobbe, "The Complete Opera Book," G. P. Putnam's Sons, New York. Pp. xxii + 993, 1935; (b) J. W. McSpadden, "Opera Synopses," Thomas Y. Crowell & Co., New York. Fifth edition, Pp. xviii + 493, 1934; (c) G. P. Upton, "The Standard Operas," Jansen, McClurg & Co., Chicago. Pp. 343, 1886; (d) P. England, "Fifty Favourite Operas," Harper & Brothers, New York. Pp. xvii + 605, 1926; (e) *Reclams Opernführer. Herausgegeben* von Georg Richard Kruse. *Zweite, erweiterte Auflage. Verlag* von Philipp Reclam jun. Leipzig. Pp. 526, 1928; (f) E. Newman, "Stories of the Great Operas and Their Composers," Garden City Publishing Co., Inc., Garden City. Pp. 322–335, 271, 1930; (g) "The Victrola Book of the Opera," Victor Talking Machine Co., Camden, New Jersey. Eighth edition. Pp. 428, 1929.

[14] J. W. McSpadden, "Light Opera and Musical Comedy," Thomas Y. Crowell Co., New York. Pp. xxi + 362, 1936.

[15] (a) J. N. Burk (Editor), "Philip Hale's Boston Symphony Programme Notes," Doubleday, Doran & Co., Inc., New York. Pp. xix + 400, 1935; (b) C. O'Connell, "The Victor Book of the Symphony," Simon and Schuster, Inc., New York. Pp. xviii + 530, 1934; (c) G. P. Upton and F. Borowski, "The Standard Concert Guide," A. C. McClurg & Co., Chicago. Pp. 551, 1930.

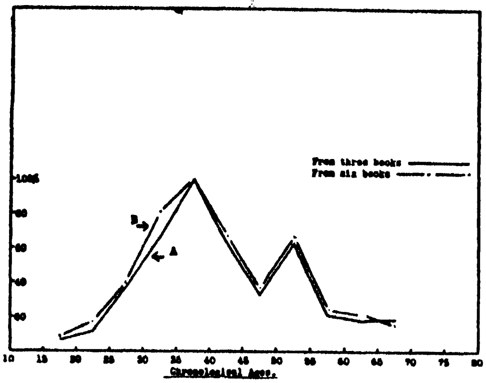


FIG. 4. AVERAGE NUMBER OF ORCHESTRAL SELECTIONS OF LASTING POPULARITY THAT WERE COMPOSED DURING EACH FIVE-YEAR INTERVAL OF THE COMPOSERS' LIVES. COMPOSITE CURVES BASED ON: (A) THREE BOOKS AND (B) SIX BOOKS—WHICH LIST FAVORITE ORCHESTRAL WORKS.

(which number includes also the three source books).

In constructing the composite curves which are set forth in Fig. 4 each orchestral selection was counted as often as it was listed. Thus, when the three source books were being examined, a selection that was listed in each of the three books was tallied three times, a selection that was listed in only two of the three source books was given two credits, and a selection that was mentioned in only one book was counted only once. This procedure is based upon the assumption that those orchestral selections which are listed by a larger number of compilers are more popular than are the selections which are listed less frequently. This measure of merit, although it is obviously a crude one, is perhaps sufficiently accurate for the purpose for which it has been used.

The two curves in Fig. 4 reveal that only a slightly different curve is obtained when six books instead of only three books are utilized for obtaining data. This finding suggests that the data possess internal consistency. Note that both of the curves in Fig. 4 exhibit rather narrow peaks, a characteristic which has received previous comment. It seems apparent that the orchestral selections which are most popular with music lovers, and which have withstood the test of time, have been composed most frequently by men of ages 35 to 39 inclusive. This was not necessarily the most prolific period of the composers of these works, but it was the most productive of works considered superior by posterity.

Contemporary Music versus Music that has Endured

In Fig. 5 the data for the dash-line were obtained from still another, a seventh, book of orchestral selections, namely, from Olin Downes's "Symphonic Masterpieces."[17] This dash-line, which presents data for 53 superior orchestral selections by 19 composers (now deceased), corroborates the findings that were set forth in Fig. 4. This curve reveals once again that the best-loved orchestral selections have been composed most frequently by individuals

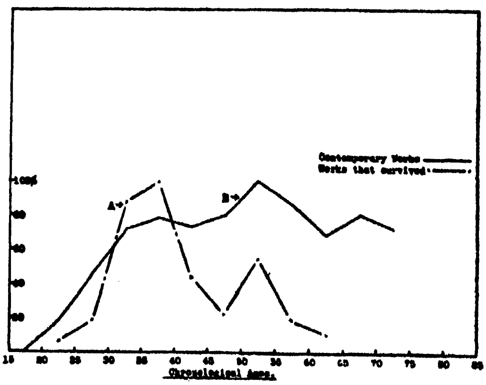


FIG. 5. ORCHESTRAL WORKS. (A) ORCHESTRAL SELECTIONS THAT HAVE SURVIVED, AND (B) ORCHESTRAL SELECTIONS WRITTEN BY CONTEMPORARY AMERICANS BETWEEN THE YEARS 1912 AND 1932.

[16] (a) L. Gilman, "Stories of Symphonic Music," Harper & Brothers, New York. Pp. xvii + 359, 1907; (b) G. P. Upton, "The Standard Symphonies," A. C. McClurg & Co., Chicago. Pp. xii + 321, 1903; (c) P. H. Goepp, "Symphonies and Their Meaning," (First and Second Series), J. B. Lippincott Co., Philadelphia. Pp. xx + 498, 1908.

[17] O. Downes, "Symphonic Masterpieces," The Dial Press, New York. Pp. xix + 294, 1935.

who were from ages 35 to 39 inclusive at the time of composition.

The solid line in Fig. 5 presents data for contemporary American composers whose works have been listed by Claire Reis.[18] In the foreword of her compilation Reis makes the following explanatory statement:

> In order to present a complete picture of the outstanding works written during the past twenty years . . . this second edition of *American Composers* has been compiled. . . . Although it may seem arbitrary to include only works written between 1912 and 1932, yet a score of years is a fair exposition of contemporary music. It is the purpose of the editor . . . to present this material with less emphasis on the complete historical survey than on the original work which has come out of this country in the last twenty years.

In Reis's volume data are presented separately for different types of music. It was possible, therefore, to tabulate separately the data for orchestral works by living American composers. It perhaps should be mentioned that many of the modern orchestral selections that are listed by Reis are still in manuscript form, not having as yet been published.[19]

Fig. 5 reveals that, whereas the orchestral selections which to-day are most preferred by music lovers have been composed most frequently by men of ages 35 to 39 inclusive, contemporary American composers, on the other hand, have produced their greatest volume between the ages of 50 and 54. However, these latter works have not yet met the test of time. Note the marked difference in the shapes of the two curves of Fig. 5. The age-curve for the contemporary American composers sustains itself well until beyond age 70, whereas, the age-curve which sets forth the most esteemed works of the deceased composers descends sharply after age 37 is attained.

In studying the two age-curves of Fig. 5 one can hardly refrain from speculation. Were the contemporary Americans composing the best as well as the greatest quantity of their music from ages 50 to 54? Or does quality of musical composition decline at earlier age levels than does quantity of composition?

Cantatas

Fig. 6 presents dates of composition for cantatas. In his book, "The Standard Cantatas,"[20] George P. Upton gives short sketches of 73 cantatas. In the appendix of this same book Upton presents a somewhat more exhaustive catalogue of 247 cantatas. The list that is given in the appendix includes also the cantatas that appear in the table of contents. It seems obvious that Upton places in his table of contents, and discusses in the body of his book, those cantatas which

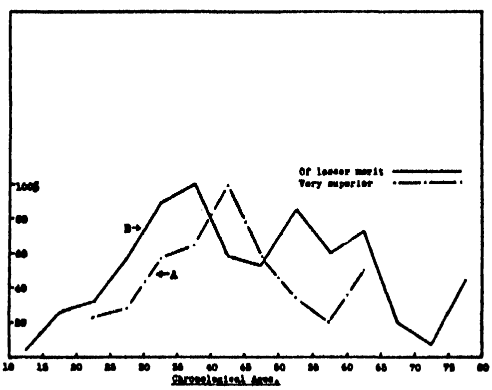


FIG. 6. CANTATAS. (A) CANTATAS OF VERY SUPERIOR MERIT, AND (B) CANTATAS OF SOMEWHAT LESSER MERIT. GROUP (B) INCLUDES GROUP (A).

he regards as having greatest merit. The 247 cantatas that are listed in the appendix are evidently regarded by Upton as

[18] C. Reis, "American Composers," second edition, published by the United States Section of the International Society for Contemporary Music, New York. Pp. 129, 1932.

[19] Since some of this contemporary music was written in 1912 and was still unpublished in 1932, one can hardly avoid the suspicion that some of it is destined to remain forever unpublished.

[20] G. P. Upton, "The Standard Cantatas," A. C. McClurg & Co., Chicago. Pp. 367, 1888.

of lesser average importance than the cantatas which are given space in the body of his book. For the more selective list which appears in the table of contents, the average number of cantatas per composer is 1.92; for the more inclusive list which appears in the appendix the average is 3.80.

In Fig. 6 the dash-line sets forth the ages of the composers at the time of composing the more selective list of cantatas (that which appears in the table of contents). The solid line in Fig. 6 presents analogous information for the cantatas that are listed in the appendix. Fig. 6 suggests that, as compared with the larger aggregate, the more important cantatas (those best-liked) are more often composed during a somewhat narrower age-range. This conclusion is suggested by the fact that the age-curve for the more selective list of cantatas reveals a rather rapid rise and decline, whereas the curve for the more inclusive list of cantatas exhibits a wider spread.

SYMPHONIES

Fig. 7 sets forth, for symphonies, age-curves that are analogous to those that are presented in Fig. 6 for cantatas. In Fig. 7 both age-curves are again based upon dates of composition. The data for

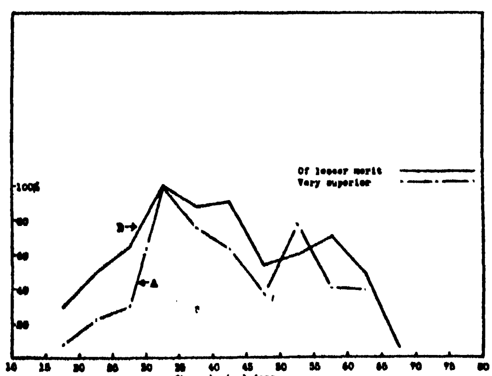


FIG. 7. SYMPHONIES. (A) SYMPHONIES OF VERY SUPERIOR MERIT, AND (B) SYMPHONIES OF SOMEWHAT LESSER AVERAGE MERIT. GROUP (B) INCLUDES GROUP (A).

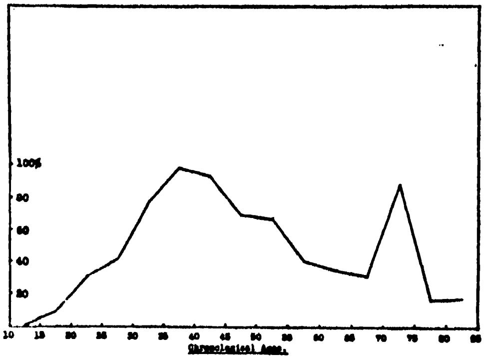


FIG. 8. AVERAGE NUMBER OF CHAMBER MUSIC SELECTIONS THAT WERE FIRST PUBLISHED DURING EACH FIVE-YEAR INTERVAL OF THE COMPOSERS' LIVES. THIS GRAPH IS BASED UPON 970 SELECTIONS BY 283 DECEASED COMPOSERS.

both of the curves of Fig. 7 were obtained from another of Upton's books, "The Standard Symphonies."[21] In Fig. 7 the dash-line is again employed for setting forth the chronological ages of the composers at the time of composing the 56 symphonies which Upton lists in his table of contents and which he evidently regards as very choice selections. And the solid line presents data for the 231 symphonies that are to be found in the appendix of Upton's book.[22] For the more selective list of symphonies (that which comprises the table of contents) the average number of compositions per composer is 2.33; for the more inclusive list (that which is found in the appendix) the average is 3.91. Fig. 7 implies that the best-loved symphonies, like the best-loved cantatas, are composed during a somewhat narrower span of years than are symphonies of lesser merit.

CHAMBER MUSIC

Fig. 8, which presents dates of first publication[23] for 970 selections of cham-

[21] G. P. Upton, "The Standard Symphonies," A. C. McClurg & Co., Chicago. Pp. xii + 321, 1903.

[22] A few symphonies had to be omitted because the dates of composition were not available.

[23] W. W. Cobbett, "Cobbett's Cyclopedia of

ber music that were composed by 283 individuals, attains its peak at the age interval 35 to 39. However, when dates of composition (which were available for 179 chamber music selections by 37 composers) were plotted separately, the peak of production was found to occur at ages 30 to 34 inclusive.

In Fig. 8 a very marked rise in the age-curve may be observed at the age interval 70 to 74. Two individuals are chiefly responsible for this phenomenon, namely, Max Bruch (1838–1920), who published 9 chamber music selections at age 72, and J. D. Artot (1803–1887), who published 12 selections at this same advanced age. It seems unlikely that these 21 selections were all composed at so late an age. It seems much more likely that in the case of both Bruch and Artot there was a considerable time-lag between the dates of composition and the date of first publication. If the latter hypothesis is valid, the unusual rise at the right of the curve in Fig. 8 is due to exceptional time-lag between date of composition and date of first publication rather than to exceptionally late composition.

Other Types of Music

Fig. 9 reveals the chronological ages at

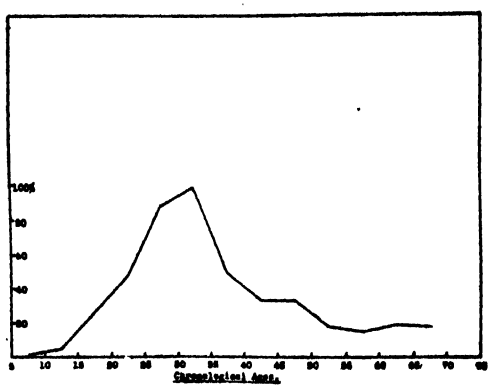


FIG. 9. AVERAGE NUMBER OF VOCAL SOLOS THAT WERE EITHER COMPOSED OR FIRST PUBLISHED DURING EACH FIVE-YEAR INTERVAL OF THE COMPOSERS' LIVES. 301 SOLOS BY 29 COMPOSERS.

Chamber Music,'' Oxford University Press, London. Two volumes, 1929.

which 301 vocal solos were either composed or first published by 29 noted composers. The foregoing statement refers to the music, not to the words, of the vocal selections. Although, for some of these vocal solos, only the dates of first publication were available, for most of them the dates of composition were obtained. Some of the data for constructing Fig. 9 were obtained from the biographies of individual composers,[24] but most of the data were procured from the 1927 edition of ''Grove's Dictionary of Music and Musicians.''[25]

It goes without saying that not all the 301 solos that are pictured in Fig. 9 are really noteworthy vocal selections. However, in obtaining the data for Fig. 9, selections were utilized only when mentioned specifically by name or by opus number, and when either the date of composition or the date of first publication was available. For example, in Schauffler's biography of Beethoven it is recorded that during one year Beethoven arranged the accompaniments to 25 Scotch songs. It seems likely that the latter figure may perhaps be a mere estimate. In any event, probably not all the 25 accompaniments were of great importance. It is here assumed that if both the name of the composition and its date have come down to us, tabulation thereof will provide a fair sampling of the composers' better vocal selections.[26]

24 (a) R. H. Schauffler, ''Beethoven: The Man Who Freed Music,'' Doubleday, Doran & Co., Inc., New York. Pp. 693, 1935; (b) H. Bidou, ''Chopin,'' (translated by Catherine Alison Phillips), Tudor Publishing Co., New York. Pp. 267, 1925; (c) W. Niemann, ''Brahms,'' (translated from the German by Catherine Alison Phillips), Alfred A. Knopf, New York. Pp. xiii + 492, 1930; (d) S. Kaufman, ''Mendelssohn: A Second Elijah,'' Tudor Publishing Co., New York. Pp. xiv + 353, 1936; (e) C. D. Bowen and B. von Meck. ''Beloved Friend'': The Story of Tchaikowsky and Nadejda von Meck.

25 H. C. Colles (Editor), ''Grove's Dictionary of Music and Musicians,'' Third edition, The Macmillan Co., New York. Five volumes, 1927.

26 Since the songs of many of the composers

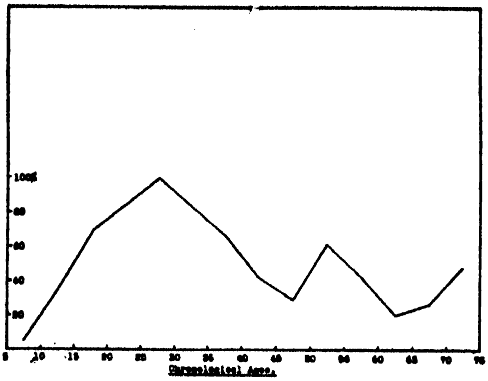


FIG. 10. AVERAGE NUMBER OF INSTRUMENTAL SELECTIONS THAT WERE EITHER COMPOSED OR FIRST PUBLISHED DURING EACH FIVE-YEAR INTERVAL OF THE COMPOSERS' LIVES. 287 SELECTIONS BY 34 COMPOSERS.

Fig. 10 presents information regarding 387 instrumental selections, mostly pianoforte and violin pieces, by 34 noted composers. Most of the comments that appear in the preceding paragraph regarding method of selection are applicable also to Fig. 10. Instrumental selections were tabulated only when mentioned specifically by name or by opus number, and when either the date of composition or the date of first publication was available. Both biographies[24a] and "Grove's Dictionary of Music and Musicians" were employed as sources of information. In Figs. 9 and 10 the age differences in creativity are clearly apparent. In each instance the peak of the age-curve appears prior to age 35. Further comment regarding Figs. 9 and 10 is perhaps unnecessary.

Contemporary Music

Fig. 11 sets forth data for 1,286 miscellaneous musical compositions by 131 contemporary Americans. The data for this graph were obtained from Reis's "American Composers." It will perhaps be recalled that Reis presents what she describes as "the outstanding works" that were written by American composers between the years 1912 and 1932, and that many of the 1,286 compositions have not yet been published. Note that the age-curve in Fig. 11 attains its peak at ages 50 to 54 inclusive, and that this curve sustains itself rather well from ages 30 to 70.

The 1,286 musical selections that were listed by Reis were classified by her according to type of composition. For four of the five types of music for which Reis presents data, the apogee of production occurred beyond age 45. Considered in the light of the other data that have been presented herein, two hypotheses will probably occur to the reader, namely: (1) As compared with the composers of an earlier day, contemporary Americans continue to compose music at older age levels, and (2) both the composers of to-day and those of the past have endeavored to produce music during most of their mature years but, for a group of individuals, the peak for quality of composition occurs at an earlier age level than does the peak for quantity of composition.

It would be difficult, if not impossible, to produce unequivocable evidence in support of either of the foregoing hypotheses. A newspaper writer advanced

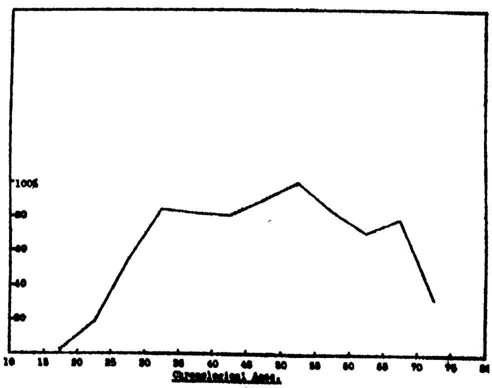


FIG. 11. AVERAGE NUMBER OF "OUTSTANDING" MISCELLANEOUS MUSICAL SELECTIONS THAT WERE WRITTEN BY CONTEMPORARY AMERICANS BETWEEN 1912 AND 1932. 1,286 SELECTIONS BY 131 COMPOSERS.

are to be found in their operas, only a sampling of their vocal selections could be obtained by this procedure.

the hypothesis that, as compared with men who lived in earlier days, modern man is able to maintain his vigor, and thus to continue his output, over a longer period of time. Therefore, it was argued, it might well be that the contemporary Americans were writing the best as well as the greatest quantity of their music from ages 50 to 54. If the foregoing arguments be valid, it is of course possible that future generations will esteem most highly the compositions that were written by the contemporary Americans when the latter were beyond 50 years of age. The latter hypothesis is submitted not as a belief of the present writers but merely as one of several hypothetical possibilities.

The preceding paragraph sets a problem for the future. Tastes change, and there is at present no sure method for determining what future generations of music-lovers will acclaim. [27] Regardless of future appraisals, the following evi-

[27] It is of interest that no composition by a deceased feminine composer is listed by the critics and historians whose works were employed in the present study. It seems apparent that modern critics do not esteem very highly the musical selections that have been written by women. Since a considerable number of feminine composers are listed in Reis's "American Composers," (See Reference No. 18) one is led to wonder how many of the works of these feminine composers will meet with the approval of future generations. And why have there been no (or only a very few) outstanding feminine composers heretofore?

TABLE I

SUMMARY OF FINDINGS WITH REFERENCE TO MUSICAL COMPOSITIONS†‡

Type of music	Source of data	No. of works	No. of composers	Average number of works per composer	Median age	Average or mean age	Standard deviation	Years of maximum productivity
Grand Opera (by Italians)	7	650	134	4.85	36.36	37.92	12.05	35–39
" " (by French)	7	569	108	5.26	40.31	42.37	14.85	30–34
" " (by Germans	7	458	142	3.23	38.80	39.87	10.65	30–34
" " (by others)	7	690	214	3.22	39.28	40.96	12.25	30–34
Grand Opera (best-liked)	11	82	38	2.16	41.25	45.12	11.88	35–39
Grand Opera (best-liked)	13a	144	61	2.36	42.64	44.44	11.45	35–39
" " " "	13b	114	39	2.92	42.92	45.40	11.55	35–39
" " " "	13c	62	22	2.82	40.50	43.47	11.10	35–39
" " " "	13d	47	21	2.24	40.50	43.14	10.65	35–39
" " " "	13e	92	43	2.24	40.70	43.48	11.80	35–39
" " " "	13f	29	11	2.64	41.00	45.78	12.78	35–39
" " " "	13g	89	34	2.62	42.20	44.07	12.20	35–39
Light Operas and Mus. Com.	14	121	54	2.24	42.17	42.71	9.60	40–44
Orchestral Music (best-liked)	15a	93	23	4.04	38.38	40.01	10.65	35–39
" " " "	15b	69	20	3.45	36.69	38.15	8.50	35–39
" " " "	15c	154	36	4.28	37.36	40.10	10.75	35–39
" " " "	16a	38	11	3.45	39.00	38.70	11.95	*
" " " "	16b	56	24	2.33	38.50	40.71	11.25	30–34
" " " "	16c	33	12	2.75	36.50	39.62	10.10	*
" " " "	17	53	19	2.79	37.83	40.14	9.58	35–39
Orchestral Music (Contemporary)	18	510	124	4.11	36.31	38.60	10.10	50–54
Cantatas (The aggregate)	20	247	65	3.80	39.23	43.07	12.95	35–39
" (A select list)	20	73	38	1.92	40.00	40.03	9.80	40–44
Symphonies (The aggregate)	21	231	59	3.91	37.80	38.95	12.30	30–34
" (A select list)	21	56	24	2.33	39.17	40.71	11.25	30–34
Chamber music	23	970	283	3.43	41.11	42.54	13.90	35–39
Vocal solos	24 and 25	301	29	10.38	31.47	33.63	11.45	30–34
Instrumental selections	24 and 25	387	34	11.38	30.28	33.00	14.15	25–29
Sacred choral music	30	111	37	2.97	45.25	46.01	14.50	35–39
Violin Concertos	31	214	103	2.08	42.08	41.87	15.25	40–44
Misc. contemporary music	18	1,286	131	9.82	36.30	38.02	9.75	50–54

* Insufficient data for determining the peak of production.

† G. P. Upton, "The Standard Oratorios," A. C. McClurg & Co., Chicago. Pp. 335, 1887.

‡ F. B. Emery, "The Violin Concerto," The Violin Literature Publishing Co., 331 West Ohio Street, Chicago. Pp. 615 + xi, 1938. Age-curves were constructed which reveal when oratorios and violin concertos are most frequently composed but these curves have not been published herein because of lack of space. The essential findings regarding these two types of musical composition are set forth in Tables I and III.

dence leads the present writers to assert that, according to present-day standards of judgment, quality of musical composition declines at earlier age levels than does quantity of composition.

To the writers it seems highly probable that the less important works of the less important deceased composers have not always been preserved for posterity and that, in many instances, no record of these less important compositions is available. Significant in this connection is the fact that the following phrases often appear in histories of music: "only fragments extant," "not given and score destroyed," "many of his early works have never been published." If, for the more prominent composers, most if not all of the titles of their works are available, study of the latter should reveal something regarding the quantitative output of past generations of composers.

Quality versus Quantity

Return for a moment to Fig. 7. Some of the composers that are listed in the appendix of Upton's book, "The Standard Symphonies," are not listed in his table of contents. Therefore, since the two age-curves of Fig. 7 are not based upon compositions by the same individuals, the difference in the shapes of the curves of Fig. 7 might conceivably be due in part to the fact that the works of different composers were utilized for constructing the age-curves. As a means of studying this possibility, the writers isolated data for 19 composers whose works were listed both in the table of contents and also in the appendix of Upton's book.

TABLE II

Average Number of Musical Compositions per Five-year Interval. The Peak of Each Statistical Distribution is Italicized

	Age interval															
	5–9	10–14	15–19	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84
Fig. 1																
(Italians)	...	...	.025	.101	.164	.153	*.165*	.141	.091	.083	.061	.047	.035	.018	.008	.020
(Frenchmen)	...	...	.006	.041	.117	*.180*	.177	.167	.139	.108	.078	.064	.081	.087	.068	.016*
(Germans)	...	.003	.006	.037	.087	*.125*	.118	.080	.069	.083	.031	.043	.020	.015	.013	...
(Others)	...	.002	.005	.038	.085	*.111*	.100	.091	.085	.072	.065	.044	.038	.017	.024	...
Fig. 2																
(*The Victor Book*)	...	...	...	...	.016	.063	*.123*	.072	.049	.040	.077	.041	.041	.046	...	.067
Fig. 3																
(Light Opera)	...	...	.007	.007	.015	.049	.100	*.117*	.102	.044	.042	.034	...	...	...	...
Fig. 4																
(Three books)	...	...	.029	.048	.157	.275	*.405*	.261	.134	.259	.092	.073	.073	...	...	...
(Six books)	...	...	.022	.044	.104	.217	*.263*	.175	.096	.176	.062	.057	.043	...	...	...
Fig. 5																
(Orchestral-Downes)	...	...	...	.011	.032	.152	*.174*	.074	.039	.095	.031	.017	.028	...	...	...
(Orchestral-Modern)	...	...	.002	.050	.129	.197	.220	.203	.221	*.278*	.240	.190	.222	.200	...	...
Fig. 6																
(Select Cantatas)	...	...	...	.026	.032	.066	.074	*.113*	.065	.038	.023	.058	...	...	...	...
(Cantatas — the aggregate)	...	.006	.037	.043	.078	.120	*.135*	.079	.072	.113	.081	.098	.027	.010	.060	...
Fig. 7																
(Select symphonies)	...	...	.008	.025	.033	*.111*	.084	.070	.041	.087	.046	.045	...	...	...	...
(Symphonies — the aggregate)	...	...	.041	.068	.089	*.136*	.120	.124	.073	.082	.097	.067	.009	...	...	...
Fig. 8																
(Chamber music)	...	.001	.013	.036	.048	.092	*.117*	.113	.083	.081	.047	.042	.037	.102	.020	.021
Fig. 9																
(Vocal solos)	.007	.028	.138	.241	.455	*.511*	.256	.174	.176	.098	.082	.103	.096	...	...	...
Fig. 10																
(Instr. music)	.018	.135	.265	.323	*.382*	.317	.255	.156	.111	.232	.162	.078	.100	.180	...	...
Fig. 11																
(Misc. contemporary music)	.001	.001	.012	.108	.329	.503	.492	.486	.538	*.601*	.505	.429	.474	.200	...	...

* The average for the succeeding five-year interval, namely, for ages 85 to 89 inclusive is .087.

Age-curves were then constructed, separately for those symphonies that were listed only in the table of contents and also for those listed both in the table of contents and in the appendix. For the 19 composers the average number of their works that were listed in the table of contents was 2.53; the average number listed in the appendix was 7.68. For the more select list the peak of production occurred at the age interval 30 to 34; for the more inclusive list the apogee occurred at ages 55 to 59.

In similar manner 36 composers were isolated whose names were to be found both in the table of contents and also in the appendix of Upton's book, "The Standard Cantatas." The 36 composers had written 68 cantatas which are listed in Upton's table of contents, and 151 cantatas which are listed in the appendix. For the more select list of cantatas the peak of production occurred at ages 40 to 44; for the larger aggregate the peak occurred at ages 55 to 59.

Grand opera was studied in like manner. Twenty-five composers were found who had contributed 75 grand operas which found their way into the eighth edition of "The Victrola Book of the Opera." For the same 25 composers 398 of their works are listed in Pratt's "Cyclopedia of Music and Musicians." For the more select list of grand operas the apogee of production was found to occur at ages 35 to 39; for the larger number of their works the peak occurred at ages 50 to 54.

Although analogous data have not been assembled for every type of music, the foregoing findings are highly suggestive. It seems likely that both to-day and in former days the peak for quality of musical composition appears at earlier age levels than does the peak for quantity of composition.[28] Since quality of composition and quantity of composition are not perfectly correlated, there is no valid reason for supposing that the contemporary Americans have written their *best* music at ages 50 to 54, their most prolific period.

CONCLUDING REMARKS

If it be granted that the sources from which the foregoing data have been obtained are trustworthy sources, it seems obvious that, although men attempt to write music during most of their mature years, for at least several types of composition, the best-loved works are produced (most frequently) during a shorter span of years than are works of lesser merit. In weighing the latter assertion it should be remembered that this statement applies to groups of composers and that any extension of group description to the individual will always be open to question.

TABLE III

AGE INTERVALS DURING WHICH VARIOUS TYPES OF MUSIC ARE MOST FREQUENTLY COMPOSED*

Ages 25 to 29

Instrumental selections.

Ages 30 to 34

Symphonies.
Chamber music (by both deceased composers and by contemporary Americans).
Vocal solos.
Grand opera (the aggregate thereof).

Ages 35 to 39

Grand opera (best-liked).
Orchestral music (best-liked).
Sacred choral music.
Cantatas (The aggregate thereof).

Ages 40 to 44

Light operas and musical comedies.
Violin concertos.
Cantatas (best-liked).

Ages 45 to 49

Stage works (by contemporary composers).

Ages 50 to 54

Orchestral music (by contemporary Americans).
Chamber orchestra music (by contemporary Americans).

Ages 55 to 59

Choral music (by contemporary Americans).

* Unless otherwise specified, the data are for deceased composers only.

Writers sometimes point to the fact

[28] A similar situation has been found to exist with reference to the writing of "best books," and data have been assembled which suggest that this generalization holds also for certain kinds of scientific endeavor. Only a part of the latter findings have been published.

that Mozart wrote four sonatas for the violin and piano at age eight, and they mention also that Mozart wrote his first symphony at this same tender age. One might point also to the fact that Mendelssohn composed his best-known work, "A Midsummer Night's Dream" at the age of 17. Those who are content to rely upon a few exceptional instances, selected to prove something, can find a number of other examples of early creativity in the field of music. But to those who have an intellectual outlook broader than that of the partisan debater, whose only desire is to maintain a pre-conceived theory, such isolated instances are of minor importance for the determination of age differences in creativity. Equally irrelevant for the latter purpose are the facts that Cesar Franck wrote his D minor symphony at age 66, Handel's marvelously beautiful "Messiah" was composed when Handel was 56, and Verdi wrote "Falstaff" when he was almost 80 years old.[29]

The relationship between chronological age and superior musical composition can be ascertained only if enough cases are assembled to yield some sort of statistical distribution. With reference to every type of human performance there are likely to be notable exceptions. However, isolated instances, and even lists of exceptional accomplishments, prove nothing at all regarding the relative creativeness of the various age groups.

Some readers who have perused this article to the present point may wonder why the writers do not advance a theory by way of explaining their findings. In the space that has been allotted them for publication of this study the writers have chosen to present factual findings with a minimum of arm-chair speculation. The decrements in the age-curves are obviously the accompaniment of later maturity. The present study does not reveal whether (for groups of composers) this decrement is the inevitable accompaniment of advance in chronological age. Nor does this study reveal specific causative factors. Indeed, solution of the latter problems may well attract the best efforts of several generations of investigators.

To some, the above findings will perhaps bring a feeling of regret. Is it possible that (for groups of composers) quality of musical composition starts declining at such relatively early age levels? In preparing this manuscript the present investigators obviously have had no choice but to report what the evidence seems to indicate.

NEW DEVELOPMENTS IN SCIENCE MUSEUM TECHNIQUES AND PROCEDURES

By ROBERT P. SHAW

DIRECTOR, NEW YORK MUSEUM OF SCIENCE AND INDUSTRY

THE technique of presenting scientific and industrial exhibits to the public has progressed a long way since the days when "half a mile of canned tomatoes" represented a high point in exhibition ideas.

The main thought behind this type of presentation, which touched the above-mentioned high a number of years ago, was obviously to impress upon the observer the importance of an industry or an achievement by staggering him with mere size or numbers. If a single can of tomatoes was a good thing in itself,

[29] Falstaff is regarded by many as Verdi's masterpiece.

then one can multiplied by many hundreds must surely be something to pause and reflect upon.

To-day, however, with the vastly increased variety of media at our command, and with a more enlightened and carefully thought-out purpose behind every exhibition program, the technique of exhibit presentation has become rather more subtle, and, we feel, considerably more effective in its approach to the public. The Chicago Century of Progress had much to do with raising the level of this technique and out of it came a number of new and useful ideas. So, too, one looks for the New York and San Francisco World's Fairs to open up valuable possibilities in this direction. And meanwhile, working along through the level stretches between the landmarks provided by such expositions, science museums and other institutions and organizations interested in the exhibition field serve as experimental laboratories where new ideas are developed and tried out—some, naturally, to be discarded, but others to become established as sound and proved methods of visual education.

If mere magnitude was the criterion by which an exhibit was measured years ago, to-day our standards are quite different. To-day, we look, first, into the value or significance of an idea and then rate it accordingly as to size of its concrete expression. For the primary purpose of any exhibit to-day is to educate, to show the public where a development, invention or discovery belongs in its own historical field and then where it belongs in the individual's every-day life. Planned by modern methods, an exhibit dealing with canned tomatoes would never, now, call in the handy man to pile row upon row of cans in one overwhelming array and let it go at that. It would call in the farmer to explain how modern agricultural methods have produced bigger, more palatable and nutritious tomatoes; the canner to describe how ripe tomatoes are picked and taken to the canning factory, there to be prepared and sealed into tins; the engineer to picture the machinery and up-to-date methods of handling that have been developed for the factory; the laboratory technician, the doctor and the dietitian to tell how research in vitamins has emphasize the importance of tomatoes in the diet and in how many ways they can be used to further the health of children and adults. All this varied information would then be analyzed and evaluated, and finally translated into the terms of modern exhibit display, actual machines, models, both static and operating, dioramas, motion pictures and other media being selected to be worked into a compact, but dramatic and many-sided picture of tomato canning as an industry in itself, and in its relation to the economic and social scheme of the twentieth century.

Keeping in mind that in these modern times the science museum must compete with the theater, motion pictures, sports events and numerous other insistent bids for the attention of the public, it will be obvious that any exhibition, whether scientific, industrial or of whatever character, must discover and put into effective use techniques of presentation sufficiently unusual to attract and hold the much-sought-after average person. Not only, therefore, are the techniques themselves of interest, but methods that may lead to their discovery are also useful.

In the following pages, we have attempted to describe some of the techniques which have been developed at the New York Museum of Science and Industry, and to suggest some of the ways in which, looking constantly toward the development of new methods, we feel out public sentiment in regard to its scientific interests.

One of the most effective ideas we have worked out recently in the field of

illumination is known as our masked lighting technique. This was developed as we were casting about for an exhibit to take the place of the famous transparent woman, which, after a phenomenally successful extended showing, was taken on a tour through the country.

This life-sized transparent figure, whose internal organs were illuminated one by one in an unusual lighting sequence, occupied the spotlight in the museum in a very literal sense for a period of six months. It was so popular, indeed, that after it left us, some two hundred or more people out of the daily attendance at the museum declared they had come specifically to see this exhibit, and were greatly disappointed not to find it. As it was not possible or practical for us at the time to construct a duplicate of this figure, and as the expense involved in obtaining one from Europe, where it was made, was prohibitive, we had to find some other way to satisfy the demand for a spectacular physiological exhibit of this character.

We did this by sending abroad for a typical medical school figure, which we named "Miss Anatomy" and with which we worked out an ingenious lighting system comprising sixteen concealed projectors to illuminate, in rotation, the various opaque organs. In order to achieve the effect desired, in which each individual organ would be brilliantly illuminated, with its natural outlines and contours thrown into sharp relief while the rest of the body would remain in darkness, the projectors were first made to serve the purpose of small cameras. By illuminating the particular containing an individual organ and a film placed in front of the or, a pattern was obtained from which a very accurate masking was constructed to bring about the required sharp cut-off in the lighting of a given part without encroaching upon the rest of the body surface. In this way, a series of sixteen sequences was developed in which one organ after another was spotlighted while a lecturer explained its structure and function.

This masked lighting technique is as readily applicable in fields other than the physiological. It might be used, for example, in demonstrating a complicated piece of machinery or equipment where it was desired to point out and explain the important parts individually. These would be successively highlighted and coordinated, leading up to an illuminated showing of the complete mechanism. Or, again, a process could be explained by breaking down its component parts into a related series of "spotlight performances."

Our progressive exhibit method of presentation is another type of technique which has been developed here at the museum and which we have applied most intensively in our electrotechnology division. The basic idea of this technique is to present to visitors, in the form of a connected story, but with exhibition media, the outstanding discoveries and developments in a particular branch of science. In the electrotechnology division, of course, we would be dealing with the story of electrical science.

Organized by this progressive exhibit method, then, our story of electrical science is told in a series of exhibit units, each one of which deals with an outstanding phase of that story and leaves it ready to be taken up by the next unit. Each individual unit consists of four parts—operating exhibits on a working level convenient to the visitor's hand, which demonstrate the main ideas and experiments with which that unit is concerned; titles and explanatory legends on the wall background; historical exhibits in a case under the working level; and, finally, a brief printed summary, in one or two lines, at the extreme bottom, condensing into a few words the significance of the material shown.

Superimposing a number of little

theaters or scientific side-shows on an exhibition to highspot outstanding features is a new development in the field of exhibit presentation which we find makes for a livelier and more dynamic atmosphere. At our museum in New York, we have some eight of these at present. One of them is the "Miss Anatomy" show, described previously in connection with the masked lighting technique. Another consists of a lecture and spectacular demonstrations dealing with Polaroid. A third demonstrates the transparent man, and so on. Each of these can stand as a separate exhibition unit by itself, yet each is definitely associated with other exhibit material in the museum. "Miss Anatomy" and the transparent man, for instance, are features of our general "Story of Man" exhibition, presenting numerous exhibits in the field of anatomy and physiology, while the Polaroid lecture-demonstrations are supplemented by other Polaroid displays outside the auditorium where the lectures are held.

A valuable purpose served by these little theaters is that they do much to offset the well-known "museum fatigue" which frequently attacks those visiting various types of exhibition. For here, when his feet give out, with the resultant numbing effect upon his mental capacity to absorb what the visitor sees, he can sit down for awhile, and be entertained while he rests.

Tying a scientific exhibition in with a motion picture running simultaneously in the picture houses is a new procedure which we have successfully employed on more than one occasion. The program grew out of a totally unexpected development in connection with what we at first considered one of the less important items in an exhibition devoted to Thomas A. Edison and his contributions to science and industry.

This was a vote recorder developed by Edison with the idea of using it in the House of Representatives to count votes. While it never went into operation there, it served a purpose as the basis of the modern voting machine.

In order to demonstrate how the vote recorder functioned, we placed the names of a number of famous people on the machine, such as Pasteur, Lindbergh, Faraday, Napoleon, Watt, Roosevelt and others, and invited visitors to cast a vote for the one they believed to have done the most for our civilization. To our surprise, when we came to count the votes we found that one name had received thousands of votes against only a few hundred for all the rest combined. This name was that of Louis Pasteur. Looking a little further into the matter, we discovered that the reason why most of the Pasteur votes had been cast was because the voters had just seen a motion picture dealing with the life of the scientist. From this it was only a step to working out a plan by which we might supplement a current feature picture dealing with some scientific subject with an exhibition enlarging upon the same subject by presenting it from other angles.

The first picture with which we felt it would be suitable to try out this experiment was "The Adventures of Marco Polo." Our exhibition presented the famous traveler as the first scientific explorer, using the little bag given him by his father to collect samples of unusual things he saw as he roamed through the Orient, which he later introduced to western Europe. The various individual exhibits portrayed modern industries which might have found their inception in that little collection of Marco Polo's treasures, among them being coal, salt, asbestos, textiles, samples of block printing, a mariner's compass and many other things.

Our most recent venture with this type of procedure was our "Submarine Patrol" exhibition, which used the motion picture of the same name as a point of departure for a showing of submarine

and subchaser equipment, featuring an actual periscope through which the public might look; under-water sound detectors, arranged so that visitors could actually hear a propeller turning in water some distance away; a radio direction-finder, set up for visitor operation; a gyroscopic compass, a "rescue lung," models of various types of submarines and chasers, and other items. As a feature attraction on one evening, during the exhibition, we had Simon Lake at the museum, discussing the development and future of submarines before an interested audience.

Our experience in this direction to date has convinced us that many interesting stories in science and industry, told so vividly in sound films, can be given added scope and reality by exhibitions of this type, using the interest already stimulated in the public by the picture to still further extend their knowledge of the scientific subject.

Our excursion around the fringes of the motion picture field led us into still another new activity, which we called "mass screen testing." Begun as one of the features of the Marco Polo exhibition, it proved so popular that we were obliged to carry it on for some time after the original exhibition closed.

Constructing in the rotunda of the museum a reproduction of one of the stage sets from the Marco Polo film, we had a lecturer use it as a stage several times a day to give a short talk on Marco Polo, briefly explaining the scientific and industrial exhibits in the exhibition and, in speaking of the set, tell something about the art of making motion pictures. In the latter connection, he referred to the screen tests taken by actors and actresses before being cast in a picture. At the conclusion of his talk, he would invite visitors to step up on the set and be "screen tested," performing for the benefit of a hidden battery of motion picture cameras such acts as taking a head test, lighting and smoking a cigarette, using powder and lipstick, or anything else the lecturer might think at the time of having them do. Our unique camera set-up permitted the filming of several individual pictures simultaneously on separate films.

Allowing the necessary time for the developing and printing of the films, the pictures were shown in our auditorium two days later, after which the films were presented as souvenirs to the individuals who had been "screen tested."

Analyzing this procedure, which drew many thousands of men, women and children from all over the country to take the "screen tests" during the few months they were held, we found five reasons for its popularity, a combination which we promptly noted down for future reference as spelling out the requisites for a successful new technique. These we listed as (1) personal participation; (2) return visit insured; (3) bring your parents; (4) bring your friends, and (5) the souvenir feature.

One thing leading to another, as it usually does, we found in our mass screen testing the germ of still another procedure, and early last summer we began figuring out a way to lure the business executive type of person into the paths of scientific interest through his favorite sport. Starting out with an adaptation of the screen-testing idea, we at first confined our "Science Aids Golf" program to the slow motion filming of an individual swinging his golf club. Following the earlier procedure, these films also were shown two days later in the auditorium, and the films then given free to the individuals concerned.

Inspired by the interest of the serious golfer in this opportunity to actually see for himself, on the motion picture screen, where his golf swing failed to conform to the necessary technique, we next conceived the idea of a golf swing

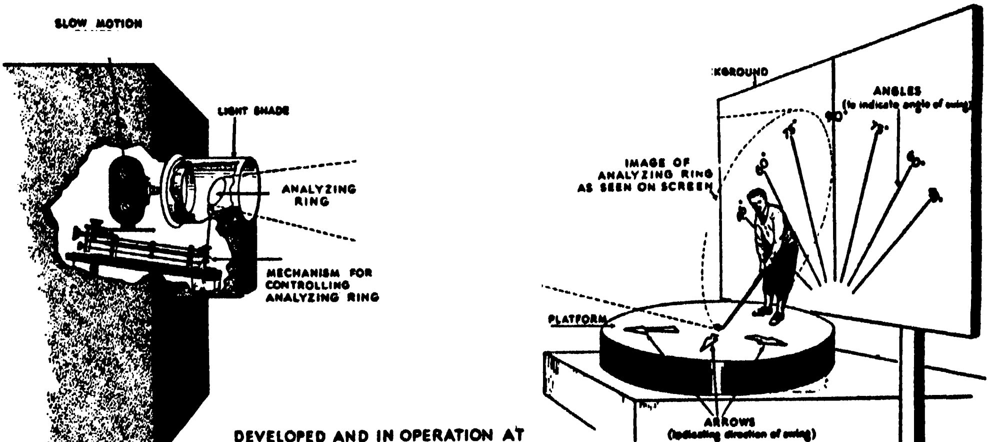
analyzer. This is a mechanism, used in conjunction with the motion picture camera, consisting of a ring, superimposed between the camera lens and the subject, and adjustable in three directions. By making slow motion pictures using this apparatus, the golfer may observe whether or not his swing follows the correct path as indicated by the machine, and, if he finds it needs correction, he can study his progress through subsequent testings.

This device, now perfected, will be put into operation at the museum within the next few weeks, but already, during the period of its development, we were satisfied that by using this new scientific method, the golfer can materially improve his game and reduce his score. It might be interesting to note that in my own case I took about ten strokes off my game, and instead of playing in the low nineties I have been consistently playing in the low eighties, and have broken eighty for the first time since I have been playing the game. Here truly is an example of how science can aid in a sport or in one's hobby.

Aside from the value of these golf tests in themselves, we have found that through them we reached people who ordinarily would not come to a Museum of Science and Industry, but who, having made this initial contact, became regular visitors.

A much more elaborate development which has come out of all this experimenting with the motion picture motif is our projected science theater, which we expect to open in the near future. This applies the screen-testing idea specifically to scientific and industrial subjects by having visitors actually perform classical experiments and demonstrations before the motion picture camera.

THE GOLF SWING ANALYZER



DEVELOPED AND IN OPERATION AT
THE NEW YORK MUSEUM OF SCIENCE AND INDUSTRY
ROCKEFELLER CENTER · · · · NEW YORK CITY

As the name implies, the science theater is really a little theater, with stage, properties, lighting effects and seats for the audience. Using our first contemplated presentation as an example of the type of thing we propose to do, the opening venture of the science theater will deal with the work of James Watt. Set up on the stage will be six dramatized exhibits, in the form of experiments, animated models or mechanical equipment, each of which will represent a highlight in the story of Watt. A short talk on Watt's work and its significance will precede a lecturer's explanation that a brief motion picture on this subject is about to be made, in which the

actors will be taken from the audience. He then explains and operates each of the six demonstrations on the stage, pointing out to the visitors that this is, in effect, a rehearsal of their rôles. After this, visitors who have previously registered and been assigned to specific demonstrations, go up on the stage and go through their respective parts.

In accordance with our established routine for this type of procedure, the pictures will be shown two days later in our auditorium, with the lecturer telling the Watt story again, this time coordinating it with the film shots being shown. Subsequently, those visitors who have appeared in the pictures may have the films to take home.

Our present plan is to change the subject of these science theater presentations from month to month, and it is our belief that such dramatizations of outstanding scientific discoveries, inventions and developments will do much to bring them to life for the average person.

In concluding this discussion of techniques and procedures at the New York Museum of Science and Industry it might be helpful to mention one we have found to be of great value as a guide in showing us what people make use of the museum, and also in helping us evaluate our exhibits from the standpoint of interest to the public. I refer to our daily surveys, in which staff members strolling about the museum enter into conversation with visitors and find out from them such data as how they happened to come to the museum, where they come from, what exhibits they enjoyed the most and other pertinent facts. A new part of the survey shortly to be instituted will consist of mailing letters to a certain number of visitors each month, with carefully worded questions designed to bring out fuller information as to what they got out of their museum visit, what type of exhibition might interest them in the future and what comments or suggestions they might have for the improvement of our presentations.

So far, our current surveys have shown that 43.8 per cent. of our visitors are brought to the museum by a desire to see some particular exhibit of which they have heard from some one who has already seen it, through the newspapers or magazines, over the radio or in some other of the many ways in which word gets around of things to see and places to go. Other leading questions used in the survey permit this figure to be broken down to indicate the relative attracting power of the individual exhibits. The other 56.2 per cent. of our total attendance come to visit the museum as a whole.

To-day, as never before, people are alive to what is going on about them at the moment. To meet their demands, to answer their questions and to hold their interest, it is important for those who plan any type of educational program to keep in mind that they are dealing with a public which is scarcely more than one jump behind the experts in knowing about the latest developments in all fields of modern activity. The radio, with its news commentators and specialized programs; the news reels and short-subject motion pictures; the up-to-the-minute digests of current topics found in the modern newspaper and the weekly news magazines have seen to it that the average person learns of the happenings in the varied worlds of politics, music, science, literature or any other almost as soon as they occur. If the science museum is not to be left behind, it must continually revise and adapt its techniques to keep them in character with the spirit of the times.

THE POLICEMAN ON THE BEAT

By Dr. READ BAIN

MIAMI UNIVERSITY, OXFORD, OHIO

AMERICA is vividly conscious of crime, almost jittery. Everybody discusses it; crime sells books, newspapers, lectures, movies and theater tickets, even games and toys for children. We have had a veritable rash of surveys, police shake-ups, raids, scientific and sensational publicity. However, the whole problem remains reminiscent of Mark Twain's famous *bon mot* about the weather, "Everybody talks about it, but nobody does anything."

The function of the ordinary plodding policeman is an uninteresting but a fundamentally important and much neglected topic.[1] He is to law enforcement what the infantry is to the army. Aviation, artillery, tanks, machine guns, intelligence service, etc., are much more dramatic and romantic, but doughboys and leathernecks are still indispensable for winning wars. Vice squads, detectives, homicide squads, G-men, radio experts, motorcycle men, laboratory scientists, captains and lieutenants are necessary for an efficient police force, but the undramatic routine of the ordinary patrolman is the basis and backbone of all good police work.

Yet the policeman is, and long has been, in very low repute with many Americans. Many mothers use the policeman to frighten children, along with boogeymen, fathers and germs. If you ask a young child what a policeman is, he may reply, "Why, a policeman can shoot you, or arrest you, or club you!" All over the land children play cops and robbers—and the cops do not always get the best of it; whoever wins, there is always plenty of shooting, clubbing, name-calling and dragging off to jail. The very word "cop" is an epithet with a rich vocabulary of synonyms such as dumb-cop, smart-cop, dick, bull, flatfoot, strong-back, weak-head, big-feet, little-brains, strong-arm squad, and so on. The policeman is the butt of crude mirth on stage and screen, in stories and funny pictures. Why is this? Why should there be ill-feeling between good citizens and the police?

Undoubtedly, the fault lies both with the police and the public. For example, the Boston Police Regulations instruct policemen to use no harsh, profane, violent or obscene language, always to be courteous and to control their tempers, to be civil, orderly, moral and never to discuss religious or political questions when on duty nor to work for any candidate at any time; never to ask for passes or otherwise to gain free admission to any place of amusement; specifically, never to say, "Can't you read that sign? Don't you know that is against the law?"[2] Other police regulations probably contain similar instructions. Citizens who have experience with the relatively few policemen who violate these rules fre-

[1] For example, in the recent S. Greer, "Bibliography of Police Administration and Police Science," New York, Institute of Public Administration, 1936, xv + 152, there are only a few references to this subject and they are mostly incidental. Perhaps the best books are A. Wood, "The Policeman and the Public," New Haven, 1919; O. F. Cahalane, "The Policeman," New York, 1923; R. B. Fosdick, "European Police Systems," New York, 1915, chapters 6 and 7, "The Uniformed Force," and "American Police Systems," New York, 1920, chapter 8, "Rank and File"; A. Vollmer, "The Police and Modern Society," Berkeley, 1936, chapter 7, "Personnel."

[2] "Rules and Regulations for the Government of the Police Department of the City of Boston," City of Boston Printing Department, 1927, 115–116, 120. It is significant that this is the latest edition of this manual.

quently jump to the conclusion that "all policemen are like that," forgetting the numerous occasions on which they have been treated courteously by policemen.

There is a wide-spread tradition among policemen that the citizen is always trying to "get away with something," that all men would commit crime were it not for fear of the police. The policeman speaks and thinks of himself as "The Law," "The Force," and he quickly adopts the clichés of his calling, such as "Tell 'em, don't ask 'em," "Treat 'em rough," "What do you think you're doing and who do you think you are?" "Tell it to the judge!" He agrees with what Grover Whalen is alleged to have said, "There's plenty of law in the end of the nightstick"; he beats 'em up and shoots to kill and goes out to revenge the death of his buddies. He adopts the theory that crime is war. It is an open question whether the "war on crime" attitude is ever a sound policy except in the figurative sense in which we speak of the war on tuberculosis or ignorance. Hopkins well says, "Crime is not war. . . . (it) is more akin to a disease in the blood."[3] The result of this antagonistic, militant attitude, this suspicious, domineering, harsh, discourteous, hard-boiled appeal to fear and force, is that the public tends to regard the policeman as an exhibitionistic bully; a stupid, inefficient coward who is never around when you need him; a grafter and political henchman in collusion with crooks; a "railroader" and "framer" of innocent men; an indiscriminate arrester; an inflicter of the third degree; a blustering threatener, over-impressed by his own importance; a disgrace to the law he is sworn to enforce. Needless to say, this is a caricature of the ordinary policeman on the beat, but it is the "picture of him in the heads" of many law-abiding citizens. It is one of those stereotyped, categorical myths which abound in our culture. While it may be untrue, it still is a social reality which must be reckoned with so long as numbers of people believe it.

There is, of course, some basis for this public ill repute of the police. Third degree methods do exist, though they are much less prevalent than is generally believed. False arrest, raids and drives, accompanied by brutality, destruction of furniture and illegal confinement in filthy, crowded jails for days and even weeks is the lot of thousands of Americans. In Dallas, 1,823 people were so arrested in the first three months of 1930 and were incarcerated for a total of more than 40,000 hours. Less than a third of them ever were charged and the convictions were almost nil. Few police departments are guiltless of similar conduct. Buffalo is notorious for the number of "confessions" obtained, and in Seattle, prisoners are frequently beaten brutally at the time of arrest in accordance with the slogan, "Nobody ever licked a Seattle cop."[4] Our policemen are looked upon by many as formidable fellows, armed to the teeth with blackjack and gun, who have a simple black and white morality which divides all people into two classes, good people and crooks, the former being those who give the police no trouble and stand in awe of "The Law" as symbolized by the officer. To this should be added the belief that they use "stool pigeons," threaten the suspect and assume his guilt, and exhibit a general attitude of intimidation rather than cooperation.

There is no doubt that the wide-spread

[3] E. J. Hopkins, "Our Lawless Police," New York, 1931, 322, also chapter 22, "Police Tradition and Mentality." See also, Howard McLellen, *Harper's Magazine*, January, 1936, 236–244.

[4] See Z. Chafee, Jr., W. H. Pollak and C. S. Stern, "Lawlessness in Law Enforcement," Vol. 11 of the National Commission on Law Observance and Enforcement, Washington, D. C., 1931; E. H. Lavine, "The Third Degree," New York, 1930; E. J. Hopkins, "Our Lawless Police," New York, 1931.

public feeling that all policemen are grafters, can be "fixed," are dominated by corrupt politicians and are generally in collusion with crooks, is highly exaggerated and unjust. Most policemen, like the rest of us, are honest, law-abiding citizens. Very few ordinary policemen ever have participated personally in the third degree, very few have ever taken a bribe; most of them are simple, underpaid, overworked and poorly appreciated men. However, because the third degree is used and because some policemen have been found in collusion with crooks and corrupt politicians, the public has formed its unfair, categorical stereotype that all policemen are grafters. For example, of 294 men leaving the Los Angeles' department in one year, 115 were discharged for the following reasons: extortion, stealing (one stole a revolver), neglect of duty, absence without leave, unbecoming conduct, suspicion of murder, grand larceny, rape and other felonies, wanted by police in other cities, intoxication on duty and other offenses.[5] While this may be an exceptionally bad record, enough similar data are known to the public to reinforce the feeling that the police are corrupt.

That policemen are neither very intelligent nor well educated is painfully apparent. The Army Alpha is one of the best standardized intelligence tests. A perfect score is 212 points; those making 135 to 212 are graded A; 105 to 134, B; 75 to 104, C+; and so on. Some years ago, August Vollmer said 75 points on the Army Alpha was the lowest limit for policemen. Such a low C+ (45–74 being C, or average) would have excluded 58 per cent. of Kansas City's force, 55 per cent. of Cleveland's and 43 per cent. of Los Angeles'.[6] Recently, it has been shown in Detroit, after nearly fifteen years of experimentation, that the best single indicator of success as a policeman, and the simplest and cheapest to administer, is the Army Alpha. Detroit now requires 100 points minimum for admission to the force.[7] Mr. Amsden, Los Angeles civil service examiner, has said, "We know from experience that unless a candidate can make a score of 120 in any one of the Alpha tests, it is useless to appoint him as a patrolman." This means that at least 75 per cent. of the policemen in the country are mentally unfit for their work. About 25 per cent. of the policemen in Los Angeles, Minneapolis, Kansas City and Cleveland get A and B ratings, while 91 per cent. of the University of California *freshmen* are in this category. The freshman had 60 per cent. A-men, while the four cities in order had 9, 7, 5 and 4 per cent. A-men.[8] In Chicago in 1931, 4,000 men were finally selected out of 22,000 applicants; 250 were recruited from the top of this list of 4,000; 215 of them got 150 points or less out of a possible 212 on the Army Alpha.[9]

If we look at education, conditions are just as bad. Somewhere around 60 per cent. have only a grade-school education. In Boston, which has one of the best police systems, of 656 added to the force, 1924–27, there were fewer than a dozen high-school graduates, 6 had attended college but none had graduated, over 300 had only an elementary school education

[5] D. G. Monroe and E. W. Garrett, "Report on Police," National Commission on Law Observance and Enforcement, Washington, D. C., Vol. 14, 61; V. D. Key, Jr., *Amer. Jour. Sociol.*, March, 1935, 624–636.

[6] L. G. O'Rourke, *Annals*, November, 19–29, 148.

[7] J. R. Searles and J. M. Leonard, "Experiments in the Mental Testing of Detroit Policemen," Detroit Bureau of Government Research, Report 141, 54 pp., November, 1936. In the first tests, patrolmen received higher scores than lieutenants (71 and 57); this was also true in the Cleveland Survey. The present explanation is that patrolmen have had more schooling than the officers and there is a correlation between test performance and amount of schooling, *i.e.*, the Army Alpha tests other factors as well as "native intelligence."

[8] Monroe and Garrett, *op. cit.*, 58–61.

[9] Bruce Smith, "Chicago Police Problems," New York Institute of Public Adminstration, 1934, 20–21.

and the remainder had spent some time in high schools, business schools, continuation schools and the like, probably until they passed the compulsory school age. Of 659 hired, 322, in order of frequency, had been truckers (80), chauffeurs (68), mechanics, laborers, clerks, taxi drivers, teamsters, metal workers, salesman, shipping clerks (15) and 119 other occupations.[10]

It is possible that these conditions have changed somewhat since 1924–1927. If more high-school graduates have been recruited, there would be a corresponding improvement in Army Alpha performance, both because ability to finish high school requires at least average intelligence and because finishing high school insures a better test performance. However, since the great majority of men on police forces have been there for some time, it is safe to say that both intelligence and education are still far too low to make possible any very high level of police work.

What do policemen read? To what extent do they keep up to date on modern police problems and professional innovations? Little is known about this, but from the above analysis, it is evident that neither by education nor intelligence can much be expected from the vast majority. Neither is there much encouragement for them to study. If one examines the current police journals he will agree, I think, with Donald Young's conclusions in 1929 that the general attitude of police journals is punitive and recreational rather than scientific and professional. Most American police journals would contribute but little to making policemen socially intelligent and technically efficient, even if they were read and understood.[11] How many policemen are familiar with modern criminological and penological theories and findings? How many have read and understood the ordinances of their city and the criminal statutes of their state? How many know anything about modern studies of juvenile delinquency and crime prevention? To the average man on the beat this is an unknown world. If he happens to hear vague references to it, his response is generally contemptuous—criminal coddlers, theorists, reformers, meddlers, sentimentalists, old maids, "professors."

In view of these facts, one is inclined to put some credence in Vollmer's statement that estimated efficiency of the police is about 10 per cent.[12] However, as Vollmer well shows, there is another side to the question. Under present conditions, the police have an almost impossible assignment. The marvel is not that they do their job so badly, but that they do it as well as they do. Poorly selected, ignorant, unintelligent, poorly trained, poorly equipped, poorly paid, poorly led, overworked, the butt of public mirth and condemnation, harassed by crooked politicians, they see a large percentage of the criminals they catch freed by shyster "criminal" lawyers, politician-judges, an antiquated, complicated and inefficient judicial system or by unscientific parole boards.[13] They are called upon to enforce a thousand silly laws passed by socially ignorant legislators; they are blamed for the failure of the church, the home and the school to rear normal, socially adjusted children; they have to make people drive 40 miles an hour while the state builds roads and permits manufacturers to build cars that call for 80 miles an hour—and the police are blamed

[10] Monroe and Garrett, *op. cit.*, 58; L. V. Harrison, "Police Administration in Boston," 1934, Appendix, 192–194 (occupations), 196–197 (education).

[11] Donald Young, *Annals*, November, 1929, 128–134.

[12] "The Police and Modern Society," Berkeley, 1936, 4.

[13] This should not be taken as agreement with the current wide-spread criticism of parole; rather it is a recognition that parole can be and must be vastly improved. It is an indispensable part of a sound penal system. See Herbert H. Lehman, *Survey-Graphic*, February, 1938, 68–72.

for the resulting deaths and injuries; they are called upon to club strikers, to enforce blanket labor-dispute injunctions and to interfere with freedom of speech; they are ordered to stop people from gambling, swearing, spitting, smoking, drinking and even from making love. If they are stupid and short tempered and unreasonable, there are plenty of so-called good citizens who are worse. Vollmer has well said:

"The citizen expects police officers to have the wisdom of Solomon, the courage of David, the strength of Samson, the patience of Job, the leadership of Moses, the kindness of the Good Samaritan, the strategical training of Alexander, the faith of Daniel, the diplomacy of Lincoln, the tolerance of the Carpenter of Nazareth, and, finally, an intimate knowledge of every branch of the natural, biological and social sciences. If he had all these, he *might* be a good policeman!"[14]

We can sum up the whole matter by saying there are two main reasons why the police experience such difficulty in doing their work: (1) the kind of people they are and (2), the kind of people we are. That is, the police organization is inadequate for the kind of society which has developed in America. It is evident that the "crime problem" can not be solved merely by improving the police. To solve it, we shall have to improve the legal and judicial systems, the political organization, the economic, educational, recreational, familial—in short, the entire social system. Here, however, we are concerned primarily with the police. It is increasingly obvious that present police organization leaves much to be desired. Stool pigeons, fear and force, the third degree, raids, drives and "treat 'em rough" tactics will not work. What should be done?

The answer is simple; the achievement is difficult. Several things are indicated: (1) proper personnel, including leadership, selection, training, pay, promotion and retirement; (2) proper equipment—the police must be better equipped than the criminal; (3) freedom from politics, especially for the executives; (4) centralization and coordination; all police work outside of cities 25,000 and over should be in the hands of the state police, with close cooperation between municipal and state systems; (5) registration of all citizens and rigid control of firearms. The police should be able to account for all persons and all firearms at all times. It should require a lot of red-tape to buy and possess a gun. Any one "losing" or illegally selling a gun should never be allowed to possess another.

What I am saying is simply that police work must become a recognized profession of high social status and decent economic security. When you have a man risking his life every day, endangering his health in all kinds of weather and being held in contempt by the community, all for $125 a month, you can not expect very much. That so few policemen are grafters is good proof of mankind's fundamental morality. That so few of them leave the force is probably an indication of their low quality. They are probably paid as much as they could get in any other line of work. Civil service gives security, even though many students of it assert that it produces mediocrity and apathy in public service.[15]

A policeman should be a college man of superior mental and physical endowment. These are some of the qualities he should possess, according to Harrison:

There are few vocations which, if adequately performed, require so much of a man—physical courage, tact, disciplined temper, good judg-

[14] *Op cit.*, 222. For some of the sociological backgrounds of conditions discussed in this paragraph, see my "Cultural Integration and Conflict," *Amer. Jour. Sociol.*, January, 1939, pp. 499–509.

[15] W. C. Beyer and Helen C. Toerring, *Annals*, November, 1929, 135–146. Turnover, around 4 per cent. (p. 145) per year. It is a lifetime job. Modal pay, $2,000–3,000 for patrolmen, but 38 of the 78 cities had maximum salaries under $2,000 in 1927–28.

ment, alertness of observation, and specialized knowledge of law and procedure. . . . If he is confronted by a dangerous situation which persons of caution would be inclined to avoid, it is his duty to enter into the thick of it. It may be a family row, a street fight, the pursuit of a desperate criminal, investigation of a burglary alarm, or a serious accident. An alarm is the policeman's cue to go into action. That he is hired to assume these burdens does not detract from the superior qualities which he is called upon to display. He must keep a cool head and take decisive action when trouble arises.

Not only physical courage but strong moral fiber is required of the policeman. He is at war with thieves, fences, and sharpers of every sort who will stop at nothing to avoid interference by police. These underworld characters are skilled in every form of trickery and deception needed to compromise a weak policeman. Gamblers, prostitutes, narcotic peddlers, and bootleggers are ever on the alert to tempt him. They do not always resort to the cruder forms of bribery, for they have gained high skill in employing subterfuges and in devising ways to bring the unwary officer under obligation.

But physical courage and moral stamina are not enough. A policeman may be courageous in the face of danger, or have strong defenses against corrupting influence, and yet be too indolent or too ignorant to perform many kinds of work which make no demands on his more admirable qualities. Moreover, tact and resourcefulness are not often balanced with decisiveness in any person's makeup. Yet tact is a cardinal requirement in the policeman. The handling of quarrelsome or difficult persons, delinquent children, and handicapped defectives of every sort demands sympathetic understanding and abundant common sense.

All of these qualities must be fused in each policeman.[16]

He should take a general course in professional police work. When he graduates, he should be eligible for a position on any state or municipal force in the United States. If he passes the examinations of the local force, he should then have an intensive training in the local police school which should bear the same relation to his college course as an interneship bears to a general medical course. During this year or two, he should learn the local police problems, acquire the morale of the force, gain experience under the direction of the older men, and then, if the executives are satisfied that he has become a competent officer, he should be given permanent status. Another possibility is for the state and municipal police departments to select promising high-school graduates and pay part or all of their expenses at some first-class police college with the understanding that they shall return for their interneship and serve at least three years. The point is that police departments should do their own recruiting rather than rely upon random applications.

Promotion should depend upon achievement as determined by a merit rating system. Nothing is worse than promotion by mere seniority or pen-and-paper examinations, except selection and promotion by "pull" and politics. Needless to say, the executive, the chief or superintendent, should have secure tenure. "Police morale is built on a foundation of honest, intelligent and continuous leadership. No single factor has contributed so greatly to police demoralization as has the practice of limiting the tenure of department heads."[17]

This discussion is not primarily concerned with the training of policemen. It is obvious that a considerable degree of specialization is necessary. This is a technical matter. We are convinced that the police profession must have a personnel as intelligent and well educated as any other profession. This applies to the man on the beat as well as the detectives, traffic officers, radio experts, laboratory men and executive officers. It is from the great rank and file that many of these specialists should be recruited. In any case, the man on the beat largely determines the success or failure of the police service.

We shall assume a patrolman who is a

[16] Leonard V. Harrison, "Police Administration in Boston," Cambridge, 1934, 28–29.

[17] Monroe and Garrett, *op. cit.*, 32. See all of chapters 1 and 2, "The Executive." See also, Andrew J. Kavanaugh, *Police "13–13,"* November, 1934, 5–6, 28.

mentally and physically superior man, emotionally mature and well-balanced, of good commonsense, of college education, technically and professionally trained. We assume that he is part of a centralized, coordinated police system, starting at about age 25, around $2,400 per year, with regular increases up to $3,600, with promotion dependent upon ability shown in service, to be retired at 50 on a livable pension, unless he has achieved an executive position, in which case he might continue to age 65. What should he do and how should he do it?

In the first place, most of the foot-beats should be abolished. A good policeman is too valuable a man to waste his time pounding pavements. His work should be done with his head, not his feet. In these days of machinery, the old-fashioned beat has largely lost its meaning, yet, in a progressive city like Boston, many of the routes have remained unchanged for thirty years.[18] An exception would have to be made for certain densely populated areas. The man on foot is probably a necessity here, but the box system and regularly covered beat should be abolished. It is essential that the crook shall not know exactly where the policeman is at any given time.

It is highly desirable that the policeman should have a definite territory for which he is permanently responsible. Thus, he can establish relations of mutual respect between himself and the citizens. He can know everybody, the particular police problems that exist, and can develop a preventive as well as protective program. When a new man is assigned, the one leaving the beat should work with him until the new man has become thoroughly familiar with the beat. It is quite unnecessary and undesirable to have the patrolman calling headquarters at stated intervals and to be at certain places at certain times. A flash signal recall system will take care of those emergencies when headquarters must communicate with the officer, and a motorized auxiliary reserve would greatly diminish, if not eliminate, most such emergencies. The officer should be able to call headquarters whenever he needs to, but not at stated intervals from stated places.

For less densely populated areas, the patrolman should be given a larger area with a radio car to cover it. The booth system should replace the present too numerous precinct station houses. The New Haven Survey shows how motorization and reduction of station houses would save that city a quarter of a million a year (one third of the total police cost) and would give much better service. According to Monroe and Garrett, only two cities of more than 300,000 have proper equipment. It is much worse in smaller cities and infinitely worse in rural areas.[19] Long ago, Fosdick pointed out that the only change in the patrol system was the reduction from two men to one man on the beat. He recommended the booth system, motorization and two men. Certainly, since the New Haven Survey showed 80 per cent. of the crimes were committed during the two night shifts, two night men, in addition to radio cruiser cars in certain areas, seem indicated.[20] Furthermore, if the patrolman is a professional man, he should be given wide latitude in the performance of his duties. Changing him

[18] J. A. Greening, "Report of Committee on Scientific Standards in Police Service," Yearbook of I.A.C.P., 1936–37, 57–75 (65–67 for discussion of beats); see also L. V. Harrison, "Police Administration in Boston," 1934, chapter 5, "Patrol, Station Houses. Auxiliary Reserves"; Bruce Smith, *Annals*, November, 1929, 1–27.

[19] "Police Department Survey," New Haven, Conn., 1934, New Haven Taxpayers, Inc., 87 mimeograph pages. See L. V. Harrison, *op. cit.*, 100–103, for discussion of equipment, patrols, etc. Monroe and Garrett, *op. cit.*, page 5 and chapter 6.

[20] R. B. Fosdick, "American Police Systems," New York, 1920, 307–310, and "New Haven Survey," cited above.

from beat to beat for fear he will get too friendly with the people, or because some beats are more difficult or dangerous than others is an insult to a capable man. To require him to report every half hour for fear he will go to sleep or loaf is also an insult and makes skilful and constructive work almost impossible. As Monroe and Garrett well say, "Where the policeman does just what he is told and no more, there will be found police inefficiency."[21]

One of the crying needs in police work is to remove the public antagonism to the police which was described and explained at the beginning of this paper. The first step is the renovation of the force. The second is a long period of service in each area so that people, particularly children and young people, may become personally acquainted with the patrolmen and look upon them as their best friends. Cahalane devotes a whole chapter to relations with children, and Vollmer has treated it also.[22] The policeman must not be a bugaboo; he must explain things to children, make friends with them, help them and gain their confidence and respect. This takes time. By the very nature of his calling, the policeman is legislator, judge and jury; he must be social worker and teacher, symbol and embodiment of law and order, of civic consciousness and conscience. He is dealing with all aspects of the most delicate human relations. He is social therapist as well as preventer of social misbehavior. He must become the hero of the children, their companion, counselor and friend. It is no job for a bully and ignoramus. This kind of work can not be covered by police regulations or orders from headquarters. It is a professional task, a science and an art.

The policeman on a beat should not carry a gun or a club. This will not seem so shocking if we remember the recommendation above that a close check should be kept on all guns in the community. We of course should not disarm the policeman until the criminal has been disarmed as completely as is possible. Those policemen who are definitely assigned to capture known desperadoes and habitual, dangerous criminals should be thoroughly armed. The ordinary patrolman has little to do with such matters. It is hard to eradicate from the minds of children the idea of a policeman who "can shoot you or club you," so long as officers go about armed to the teeth looking for some one to shout at or "run in."

The idea that police work consists primarily in catching criminals and frightening people so they will not commit crime is a most serious misconception, both on the part of the police and the public. It is largely responsible for the failure of the police. Fosdick has said that Europeans like and respect the police.[23] Here, we dislike them and do not respect them. This can be remedied only by a reformation of the police and a corresponding change in public opinion. The policeman must first achieve a fundamental respect for himself and the public. Then the public will respect the police. O. W. Wilson has well expressed this: "The essence of a proper police attitude is willingness to serve. We must not confuse servility and service, nor courtesy and softness. . . . We must be firm, but at the same time, courteous. We must avoid an appearance of rudeness." He goes on to say that good public relations can not come from mere propaganda—to "sell the police to the public is selling it down the river!" The police must commend itself to the public by serving it well; informing it through publications, by speakers, by activity in citizen groups, by displays, by inviting public inspection. The appearance and

[21] *Op. cit.*, 27.

[22] C. F. Cahalane, "The Policeman," New York, 1923, chapter 13; Vollmer, *op. cit.*, 189 ff. and chapter 7.

[23] R. B. Fosdick, "European Police Systems," New York, 1915, 234–236.

presence of policemen, the advice and instructions which they give to business men, the welcome and assistance they give to newcomers in the community, visits to homes, work on playgrounds, at schools, recreational centers and parks—these and many other services will commend the police to the public.[24]

Most Americans are not criminals nor potential criminals. Most of them are men of good will and good citizens. Most police work is regulatory, advisory, directive. The sooner we develop a conception of police work in harmony with these facts, the sooner we will be on the right road toward the curbing of crime in so far as police work can do it. The policeman should conceive himself as an intelligent social worker, as a preventer of crime, not as catcher of criminals; as a community servant, not a watch dog and symbol of fear; he should think of his calling as one of the learned professions, of himself as an expert in the adjustment of delicate and complex human relations. In short, his work is an art dependent upon thorough familiarity with the rapidly developing social sciences.

Able police forces, properly trained, properly equipped and wisely led, organized according to principles now known, could do a great deal to control crime. They could catch and convict more criminals, to be sure, but they could do still more to control crime by preventing it through intelligent police work, especially with children and young people. Intelligent police leaders and informed citizens are becoming conscious of these simple facts. A new day is dawning in the whole area of crime control. In the future, we shall pay more for our police services, but we shall get vastly more for our money. In the long run, it will be one of the most productive forms of social investment.

Then, instead of contempt and fear, children and adults will have respect and admiration for the policeman on the beat; then we shall equal and surpass our European neighbors in the handling of crime. We shall demonstrate that a democracy can keep its communal house in order without departing from the fundamental principles of democracy—a maximum of freedom with a minimum of restraint, a fundamental respect for the dignity, personal rights and privileges of the ordinary citizen. Scientifically organized police systems manned by truly professional police officers, and especially by socially intelligent, professional policemen on the beat are powerful and indispensable prerequisites for the realization of this democratic ideal to which all good Americans must give their undivided loyalty. Within reasonable limits, we can solve all our social problems. The problem of crime is no exception.

[24] O. W. Wilson, "The Police and the Public," Yearbook of the I.A.C.P., 1936–37, 46–55, especially 47–48. See also, Cahalane, *op. cit.*, 8–11; A. Wood, *op. cit.*, entire book; Vollmer, *op. cit.*, chapter 7.

GREAT LANDED ESTATES IN THE MEDITERRANEAN REGION

By Dr. RAYMOND E. CRIST

DEPARTMENT OF GEOLOGY AND GEOGRAPHY, UNIVERSITY OF ILLINOIS

Introduction

LAND is a fundamental resource, and, together with climate, it has been the object of intensive study. But we should not too readily conclude that the number of people in a given region and their activities depend solely upon the qualities of the soil and climate. There is another very significant factor which has all too often been only very briefly considered or overlooked entirely, and that is, who owns the land. For example, Mexico is spoken of as a beggar nation sitting on a pot of gold largely because of the concentration of land in the hands of a few families. Abject misery for millions of peons has been the result. The entire history of the southern states of the United States differs markedly from that of the northern states, less because of differences in soil and climate than because of the growth of the plantation system before the Civil War and the development of the institution of share-cropping since that time. In Denmark it has been the policy of the Government to distribute land as equitably as possible, in accordance with the principle that "very few should have more than they need and fewer still should have less than they need." As a result of this policy Denmark has become a country of prosperous small landholders, one of the richest agricultural nations of the world. Denmark has about the same soil and climate as East Prussia, yet the latter is rather sparsely populated by poor peasants because the land is concentrated in the hands of a few powerful Junker families. These marked differences in development between Denmark and East Prussia are due rather to the different systems of land tenure rather than to differences in soil, climate or race of people.

Great Estates Common in Mediterranean Basin

Large landholdings are an important factor in the Mediterranean region. Sometimes they are of feudal origin; others have resulted from the encroachment of great landlords upon either small individual or large communal holdings; still others are huge grants awarded to some successful military leader. In the Balkans the victorious Turkish chieftains appropriated great blocks of land, or "tchifliks," often merely ousting the Christian landlords. In Syria large estates are the rule, especially in the cereal country east of the coast ranges. In Algeria after the French conquest huge concessions were made to companies and to individuals, particularly during the Second Empire. Great landholdings, or "latifundios," are quite wide-spread in Spain, while in Sicily 1,400 estates comprise 30 per cent. of the total area of the island. Great holdings are prevalent in Italy, both in the Po Plain, where intensive agriculture obtains, and in the extensively farmed regions of southern Italy. Even in the French Midi large estates (over 10 hectares) are becoming general, taking up from 35 per cent. of the cultivated land in the eastern Pyrenees to 50 per cent. in l'Aude.

Unfortunately, great landholders are not, as a rule, convinced that *noblesse oblige*. Their estates are simply farmed extensively under the supervision of a resident manager, and, the owners being assured of ample income without risk and without effort, they make no attempt to increase production and thereby raise the standard of living of the miserable peasant. This has been true from one end of the Mediterranean to the other. It is easy to blame the climate or the "Latin

temperament'' for the growth of brigandage, the vendetta or the maffia, depending on the region, instead of unemployment, very low wages and the consequent miserable living conditions for which bad harvests and the greediness of usurers have been largely responsible.

Some Advantages of Great Landed Estates

Centuries of experience have taught the Mediterranean peoples that landholdings below a certain size are not stable in regions where harvests are likely to be uncertain because of droughts. Methods similar to those employed in modern *dry farming* were mentioned by Homer, Xenophon, Theophrastus and Virgil. Because of the immense amount of hand labor required before the advent of modern methods of mechanized agriculture, especially when cereals were the main crop, slavery was in vogue during ancient times, serfdom during the Middle Ages. By the fourth century, B.C., in the city-state of Athens, small landholdings were gradually acquired by rich money-lenders till large holdings were the rule. The history of European colonization in North Africa has conclusively proved that in those areas best adapted to the extensive production of cereals only large-scale holdings can survive. It is easy to draw parallels between such areas and our great wheat-producing states. North Africa might well be cited as an obpject-lesson to those who look with misgivings upon the development of vast machine-cultivated holdings in the Spring Wheat Belt of the United States. The rainfall, at all events, is independent of political systems, so, although 160 acres may support in comfortable circumstances one family—or even two—in the Corn Belt, the same is not true in the Wheat Belt—no matter how much wishful thinking be done.

Large Landholdings in Apulia

In southern Italy in the province of Apulia there are many great landed estates on which most of the work is done by day laborers. Here agriculture has the characteristics of the industrial undertaking for two reasons: (1) The amount of precipitation varies greatly from year to year, causing great fluctuations in total annual crop yields. Large estates can survive such uncertain conditions better than small holdings, (2) The agricultural products are for the most part not consumed locally; hence, they are subject to the vagaries of distant markets. Here again the margin of safety is not great enough for the small peasant.

Latifundios in Spain

The present system of land tenure in Spain dates largely from the time when the industrious Moors were expelled. Their land was confiscated and parcelled out in immense estates to the Catholic Church, to noble families and to army officers of high rank. The estates were really feudal fiefs, and the people living on them became serfs, attached to the estate. And as a result of the law of primogeniture, many of these estates have remained almost intact even to the present day, after more than 400 years.

In the course of centuries the great estate became a business enterprise on which a certain income was to be realized annually. Naturally the owner would prefer extensive cultivation of a crop that could be planted and harvested without high labor costs. No attention was paid to the needs of the people or to diversification of crops. One-crop farming was the rule. Formerly it was believed that latifundios represented only agglomerations of poor land. Surveys have shown this belief to be untenable. The province of Alicante has almost twice the population to the square kilometer (96) of the province of Seville (56). Both are equally fertile, but Seville is to a large extent in great landed estates. In Valencia, where small landholders prevail, the value of the yield of cultivated land averages 985 pesetas annually,

whereas in the rich province of Seville, with its latifundios, the annual average is only 401 pesetas—less than half as much.

And now some statistics with regard to the extent of concentration of land in the hands of a few. Spain's three greatest landowners, the former archdukes of Medina, Peñoranda and Alba, control more than 420,000 acres, and the next five largest holders control more than 145,000 acres. Thus the eight largest landowners control more than 465,000 acres of the best farm lands in Spain. Twelve hundred families own more than 40 per cent. of all the agricultural land in the country, and another 20 per cent. is owned by 75,000 families. If this same condition existed in the United States it would mean that approximately 7,500 immensely wealthy families would own almost one half the land of our country. And now I wish to show how this concentration of cultivable land in Spain in the hands of so few people has resulted in a terribly low standard of living for millions of peasants.

The great latifundios require few workers and then only at certain seasons. A limited range of crops gives rise to great seasonal fluctuation in employment. High wage rates may exist for the rush season, but the wage in no wise suffices to carry over a family to the next peak season. For this limited economy the owners of the immense estates have been to a large measure responsible, and only under the Republic, after decades of social trouble and anarchy, have serious attempts been made to seek greater range of crops.

An added exasperation is that the seasonal demand may require importation of labor from far provinces, which gives rise to the anomaly that, in an area noted for rural unemployment, migrant labor must be called in. The three crops of Andalusia—cereals, olives and vines—give some spread of labor; but in Castile wheat and barley are the only crops, and even these vary enormously in yield according to the variations of rainfall. The plight of the rural laborer is pitiable in the extreme.

The English geographer, Mr. Dobby, in an article on "Agrarian Problems in Spain" in the April, 1936, issue of the *Geographical Review,* gives a graphic picture of the distress of the laborers and the attitude of the landowners. I quote, "I recall an incident during a visit to an experimental pig farm in an out-of-the-way part of Andalusia. From the darkness at one end of the building came a red glow. I went along and found a laborer's family crouched on the floor round a twig fire with smoke so thick that breathing was difficult. The malodorous squalor contrasted with the carefully washed pig pens that I had been seeing. To my query an old woman mumbled: 'Yes, we live here. Worse than the pigs.' At which the owner beside me exclaimed indignantly: 'You have a roof over your head. What more do you want?' "

The consequences of the great landed estates have been: depopulation of the countryside, inefficient methods of farming, very low average wages, high rents, scarcity of live stock and a generally precarious economic situation for about a third of the country. In whole regions, as a result of a too rainy or a too dry season, a windstorm or a bumper crop with a consequent sharp drop in prices, the entire population may be reduced to the verge of starvation. Small wonder then that the people of this vast rural slum of Andalusia have for a half a century been ready to follow any political party—anarchosyndicalist or socialist—that has promised speedy and sweeping agrarian reform.

One of the first acts of the new government, when the Republic was established in 1931, was to write the law of agrarian reform—formulated in September, 1932. The law defined the properties liable to expropriation, established cooperative societies and encouraged agri-

cultural instruction. The breaking up of the estates was begun in 1932. Although the great landlords concerned, only 25,000 in the entire country, were to be paid off gradually in the course of a generation, they at once became bitterly hostile to the new government. The church property, valued at $500,000,000, was nationalized in 1933. This act served to make the Catholic Church implacably hostile to the new régime.

But most of rural Spain still seethed with misery, and at last in February, 1936, general elections were held. The result was an overwhelming victory for the left Republicans and the workers' parties. With this tremendous showing of popular support of the new government felt justified in going ahead with land reforms. One of the first decrees of the Azaña Government was that of February, 1936, which stopped payment of all indemnities which the preceding Right Government had granted the great landlords for their expropriated estates. In the first days of March, 1936, rural workers and tenant farmers returned to the lands allotted them by the first agrarian reform, which were taken away from them during the Right reaction of 1934–1935. Thus the Institute for Agrarian Reform noted that within a single week it had "installed" on the lands at its disposal 17,114 families of rural workers or tenant farmers. As a matter of fact these people installed themselves on the plots originally granted them which were subsequently taken away.

The large landholders were no longer allowed to continue keeping valuable land uncultivated. Much excellent land, for example, had been withdrawn from cultivation in the Guadalquivir Valley to be used as pasture land for the bulls destined to be killed in the bull fights. The new law made it compulsory to rent this land to the starving peasantry.

The breaking up of the great landed estates and the nationalization of the property of the Roman Catholic Church made the two most powerful elements in Spain deeply hostile to a government duly elected by a huge majority. The landlords and the clergy were willing to do anything to overthrow the government, even to the calling in of foreign mercenaries. But it is hard to see how a government can be stable if foreign troops are necessary to impose it on an unwilling people.

The system of slavery formed the material basis on which a flourishing culture was developed by the ancients, but once the iron grip of Rome was loosened the ancient world was precipitated into definite ruin, and the Dark Ages intervened before another culture could come into being. "In speaking of Mediterranean civilizations it is necessary to distinguish, on the one hand, that which constitutes for them a durable, ever-valid basis from that which, on the other hand, has not been, in the history of human societies, but a unique and transitory success, the glamor of which should not mask the inherent defect."[1] Franco's régime, once installed, may be a transitory success, but the inherent defect is that it will have been imposed by outside force. The land problem must either be solved or the population subjected to a modern Inquisition.

CONCLUSION

By way of conclusion allow me to quote the concluding sentences of my review of Pascual Carrion's great work on latifundios in Spain. This review was published in the April, 1936, issue of the *Geographical Review*. I quote: "All other problems in Spain fade into insignificance beside this one of agrarian reform. According as it is or is not satisfactorily solved, millions of people either will achieve a standard of living to which human beings are justified in aspiring or will continue to vegetate in illiteracy, misery, and squalor."

[1] Charles Parain, "La Mediterranee, Les Hommes et Leurs Travaux," p. 209. Librairie Gallimard Paris, 1936.

CULTURE AND CIVILIZATION IN GUATEMALAN SOCIETIES

By SOL TAX

CARNEGIE INSTITUTION OF WASHINGTON

Dr. Redfield writes that in Yucatan there is a gradual retreat from the city, as a representative of modern civilization, to the villages in the interior as representatives of folk culture. On a more or less common cultural base, specific and striking gradual changes are seen to occur in space from the villages through the larger towns on the railroad to the city of Merida; and in a general way the differences reflect the changes that have occurred in the course of time. The evidence points to the conclusion that the intermediate "towns" were once culturally akin, in certain respects, to the villages as they are seen to-day, and with the advent of the railroad have been and are being gradually assimilated (in these respects) to the civilization of the city.

The differences between the village and the city, therefore—since they represent the course of cultural change in Yucatan—are especially significant, and Redfield justly sees in them a suggestion of more universal application than to the field of Yucatan alone. He defines the difference between the village and the city in terms of a difference between "culture" and "civilization," and says of it:

> The one type of society, approached in the village, is a relatively immobile society, culturally homogeneous, in which the ways of life form a single web of interrelated meanings. This culture is closely adjusted to its local milieu. Relationships are personal, and the important institutional controls are familial. The sanctions which control conduct are prevailingly sacred, piety is emphasized, and custom has the force of moral rule. Ritual is highly developed, and expresses vividly the wishes and fears of the people. On the other hand, as one leaves the village and moves through the town to the city, one goes toward a contrasting type of society. This society is much more mobile, and culturally heterogeneous. The ways of life are less closely interrelated; group habits exist more in terms each of itself, and do not to the same degree evoke a body of closely associated definatory acts and meanings. These ways of life rest upon, but are not of, their natural environment. Relationships are increasingly impersonal, and formal institutions qualify the acts of the individual. The familial organization is much reduced in importance as an instrument of control. Life is secularized; economic advantage and valuation have penetrated the social body; and the individual acts from constraint or convenience rather than from deep moral conviction. Religious belief and action are much reduced; the individual can no longer express himself in the comfortable grooves of sacred ritual.[1]

Since this was written, the Carnegie Institution has extended its ethnological researches into the highlands of Guatemala, and we have had the opportunity to consider certain towns there in the light of Dr. Redfield's experience in Yucatan. Although the work has by no means progressed to a point comparable with that in Yucatan, certain contrasts in the two regions are demonstrable.

Historical considerations would lead one, offhand, to suppose that the sociological conditions in Yucatan and Guatemala would bear close resemblances. Geographically the two regions are close: the highlands of Guatemala rise practically from the southern edge of the plain of the peninsula of Yucatan (with, however, an almost impassable and uninhabited area between the highlands and the northern part of Yucatan about which Redfield writes). Linguistically, the Indians of both places speak

[1] Robert Redfield, *American Anthropologist*, 36: 68–69, 1934.

languages of the Maya stock, although different branches. Culturally, at the time of the Conquest both regions were certainly part of one culture-area, and even to-day there are many close resemblances of both material and non-material culture. On this common base the same Spanish conquistadores and the same Spanish colonists came in at about the same time; and now each place is subject to about the same influences from the complex civilization abroad.

Yet the fundamental ecological set-up of what Redfield calls the "gradients of civilization" is quite different. The peninsula of Yucatan

> is a single geographic region: a forested limestone plain. The rainfall increases as one goes southeastward until it is so great that human habitation is difficult. Merida, the capital city, is located in the northwest corner of the peninsula. This is the center of contact and of influences political, social, and cultural. From this point the roads and railroads move outward, becoming, in the southeast, trails through the bush. These trails, as one continues to move southeastward, become less frequent and less traveled, until one reaches the isolation of central Quintana Roo, where the Indians are visited only by the chiclero and the occasional traveling merchant.[2]

There is a regression from the characteristic city ways of life in Merida through the intermediate towns as they are farther away on the railroad to the folk ways of the villages off the beaten paths.

To this, the picture in Guatemala bears hardly any resemblance. On an east-west axis, the capital of Guatemala is about in the center of the highlands. Since it is the section most typically Indian (as well as the only one we have so far studied) we need here consider only the highlands to the north and west of the capital, Guatemala City, which is to Guatemala just what Merida is to Yucatan. Since in this region the country is mountainous and irregular, rather than a plain, one might think that the influence of the capital would fall off even more rapidly, as one leaves it, than in Yucatan.

Such a comparison is, however, not fruitful, for conditions are too dissimilar. The gradient of civilization in Guatemala does not at all accompany geographic distances. It happens that in Guatemala the self-perpetuating class of Spanish-speaking non-Indians, called *ladinos*, have become settled in fairly large towns distributed all over the highlands with no relation to distance from the capital. These towns have all the cultural advantages, for the ladinos, and many of the characteristics, of Guatemala City itself. There are good automobile roads to all of them, and daily freight and mail service; newspapers and the material conveniences of life are easily available. Telegraph and telephone lines come to all of them. Each has a quota of large stores visited frequently by the representatives of importers from the capital, and their stocks of goods are kept up to date. Each has its electric light plant, its water system, its printing presses, its library, its schools. The wealthier of the ladinos own automobiles, and travel frequently to the city, where many of them have homes. There is hardly more cultural-lag from the capital to these towns than there is from New York to the cities of our middle-west.

Thus civilization is represented evenly in every section, and what gradient there is is describable from any of these towns, or the capital, to the country back of it or between two of them. In this country there are smaller settlements of ladinos, who are generally a short step behind their fellows of the larger towns in education and material progress; but most of it is populated by Indians, some of whom also live in small towns but who for the most part live on their farms surrounding and between both the smaller and the larger towns. These Indians constitute 90 per cent. of the population;

[2] *Op. cit.*, p. 62.

they are direct descendants—racially, linguistically and culturally—of their pre-Conquest forbears of the region; in every sense they are fairly comparable to the Maya Indians of Yucatan. To the casual observer they appear to be, indeed, more purely Indian, and ostensibly even better representatives of folk-culture than those of the villages described by Dr. Redfield. The fact that they are as close, physically, to civilizational influences almost as the very suburbs of Merida, not to mention the town on the railroad about which Redfield writes, naturally suggests that they may be well on the road to deculturation.

That this suggestion is highly pertinent can be seen from a consideration of how very close the physical contact really is. The Indians are territorially divided into so-called *municipios*, or townships; each of these has a town in which are located the official buildings, the church and the market-place. The Indians take turns being officials—both political and religious—so that all of them, for fewer or more years of their lifetimes, are resident in the town during their terms of office. In addition, the town usually has market one or two days a week, and most of the Indians come in to spend the day. Furthermore, on occasions when there are religious feasts or ceremonies almost all of them come to the town to stay for several days or a week. And finally, all business concerning land and many disputes of whatsoever character bring individuals to town almost any day in the week or year. Now some of the municipios have for their town-centers just those large towns that are populated by urban ladinos. Naturally, in these places the Indians have the closest of contacts with civilization. They see the houses and the clothes of the ladinos, they become acquainted in the stores with the novelties of the outer world, and they see practiced—and hear about—modes of behavior different from their own.

Indians who live in municipios the town-centers of which are *not* inhabited by ladinos do not, of course, have so frequent contacts with civilization. Nevertheless, they are far from isolated. Most of the Indians are inveterate travelers; some are traveling merchants, and they of course spend most of their time in the markets of the larger towns or traveling between them. But even those who are not merchants like to go to as many markets and fiestas as they can, if for nothing more than to see many faces. Men, women and children are habitually "on the go," and in most cases they visit the larger and more important towns—those, again, with the ladinos. Furthermore, Indian officials in the smaller places (and every man is one sooner or later) are obliged to visit the larger towns frequently on official business. Thus on the whole there are few men [though more women and children] who have not seen samples of the material goods or been exposed to the influence and ideology of modern civilization.

Whether or not this contact has had its expected effect—whether or not the Indians have been or are being deculturated—is a question not to be answered directly or conclusively, since it is not possible to view them two or three generations ago. But two points can be made—points significant in the resolution of the problem raised by Dr. Redfield's paper.

The first is that in certain definable respects the Indians represent folk-cultures quite as much as any in Yucatan. They are, indeed, far *more* backward, in literacy, education and a knowledge of what goes on in the world, than the people of the village specifically described by Dr. Redfield. They are as unworldly as the most isolated of primitive peoples. Their methods of agriculture, their food, clothes, utensils and their mode of life, as well as their beliefs concerning nature and the supernatural, bear next to no relation to their proxim-

ity to the influences of civilization. Moreover, they are more like primitive tribes than the Indians of Yucatan. The Indians of each municipio speak a common dialect peculiar to themselves; they have their own particular costume, they disapprove of intermunicipio marriages, they have a name for themselves as a people, they have a strong ethnocentric feeling, they have a distinct political and religious organization, economic specialties and even standards of living that may be peculiar to themselves, and, finally, in their general world-views, beliefs and individual cultural practices they tend strongly to be homogeneous in the municipio on the one hand and, on the other, set apart from the people of other municipios. In these respects the Indians of Guatemala are certainly "folk" as Redfield defines the term.

Why the culture, in these respects, is maintained in the face of apparently adverse conditions is not too difficult to explain. Since the Indians are uneducated, ignorant and unworldly, the newspapers, the telegraph and the telephone, not to mention the ideas entertained by the urbanized ladinos, mean next to nothing to them; and if their contact with these things is physical, it is not actual. The influences do not penetrate; the Indians are exposed, but can not receive. Furthermore, they are on the whole too poor to receive the material advantages of civilization. Radios, even should the Indians understand their usefulness, would be far beyond their reach; indeed, their pocketbooks do not extend even to flashlights, which they do understand. In Yucatan, by way of contrast, the policy of the government has been consciously to educate the Indians, to make them aware of and to want new ideas and things.

Another reason why the Indians need not receive simply because they are exposed is found in the pattern of their culture itself. In contrast to Yucatan, where there is really only one culture, the Indian groups of Guatemala differ from one another in the ways that I have mentioned, and this in the face of continual contacts of individuals of one group with those of another. They are used to seeing differences and to ignoring them. They recognize that "the Indians over there" have this or that custom different from their own, and on the whole, while they are tolerant of it, they do not adopt it. This characteristic, so often in evidence among the Indian groups themselves, is naturally brought into play in their contacts with the ladinos. If the urbanized ladinos are known to think or do in another way, that is their business—quite to be expected—and has nothing to do with the Indians. Thus whatever influence the proximity of civilization might have is effectively nullified.

The second point is that in other respects the Indians of Guatemala, far from resembling Redfield's typical *folk* culture, actually fit the criteria by which a city-type is judged. Indian society, even in one municipio, is relatively mobile; individuals and families shift both their economic positions in the community and the respect in which they are held, with comparative ease and frequency. Relationships are surprisingly impersonal, and familial organization is, if anything, at a lower point in social control than even among us: the formal organization, as represented by the Indian officials in the town hall, and by the elders of the community (a definite and organized group) is resorted to in all manner of dispute even in the primary family. The activities of life—economic, social, political and religious—are in a real sense secularized; individuals in all matters which give them relatively free choice act from thought of personal gain, and the necessities of the community must be filled by forcing individuals to contribute. Religious action on the part of individuals is at a minimum, with specialized communal organizations per-

forming almost all rites that are deemed necessary in common belief. The ideas back of Indian relations and activities themselves in most of their aspects are, as Redfield has analyzed them, city-like and civilized.

Does this mean that in fact the contacts with civilization have had their expected effects after all? Have the Indians—while still illiterate and unworldly—been affected in their social organization and means of social control? Are they, in these important sociological respects, deculturated?

To answer "Yes" would have this important implication: that on the whole, Dr. Redfield's extract of general terms from his Yucatan experience takes on added significance and force, since by even formal contact with outside civilization, groups more primitive even than in Yucatan show the effects of deculturation even without an advance in sophistication.

To answer "No" would have contrary but equally significant implications:

(1) The influence of outside civilization—notwithstanding the close physical contacts—would appear to be extremely small; a study of the reasons might throw much light on the mechanisms by which western civilization *does* influence native tribes.

(2) We should be forced to conclude, in terms of Dr. Redfield's conceptions, that the Guatemalan societies represent neither culture nor civilization, but a combination of both. Further, if the Indian communities are not to be considered simply in transition, we must recognize that a stable society can be small, unsophisticated, homogeneous in beliefs and practices and still be mobile, with relationships impersonal, with formal institutions dictating the acts of individuals, and with familial organization weak, with life secularized, and with individuals acting more from economic or other personal advantage than from any deep conviction or thought of the social good.

It is natural, therefore, that I hesitate to answer, especially since the proof of this kind of assertion must consist more of judgment in the interpretation of facts than of clearcut facts themselves. Yet it appears to me that the answer is "No"—that modern civilization as it is represented in Guatemala City and in the ladino towns of the highlands has almost nothing to do with the apparently un-folk-like character of Indian social organization. I do not assert that that organization is pre-Columbian, for it obviously is not; I do believe, however, that its essential characteristics are not recent innovations, that they are explicable in terms of themselves, that the culture is an integrated and consistent whole the peculiarities of whose social organization are matched by fundamental behavior and cultural patterns existing in the communities.

BOOKS ON SCIENCE FOR LAYMEN

ALCOHOL AND THE INDIVIDUAL[1]

THE problem of unwise indulgence in alcohol is one which seems to have been always present. Unfortunately the approaches in the past have been too largely based on ethical, religious or penal grounds, and none of the approaches seems to have been conspicuous for its success. The statistics of courts and correctional institutions indicate overwhelmingly the futility of dealing with drunkenness as a crime; and the results of the late lamented experiment of prohibition appear to indicate that fiat legislation with regard to alcohol is not a success. That drinking, far from showing a decline, is on the increase, particularly among young people, is shown by some statistics quoted by Strecker and Chambers in the "Introduction" of the present volume, which show an increase of 183 per cent. of rejections by one life insurance company "involving heavy alcoholic indulgence" in the age group under 30 from 1931 to 1936.

The problem of alcohol, then, is still with us, and it is encouraging to find a volume like that by Strecker and Chambers, which describes a reasonable approach to the problem of drinking from the psychiatric point of view. Dr. Strecker is professor of psychiatry at the University of Pennsylvania and one of the very prominent psychiatrists of this country. His co-author, Mr. Chambers, is described in the "Introduction" as one who himself has been an alcoholic and who has not only cured himself but has made a close study of the factors involved in alcoholism and its treatment. The volume points out that the medical value of alcohol is slight, indeed; that it is a narcotic drug, but that by its release of inhibitions it serves a purpose, in the case of those who are able to use it intelligently, as a social lubricant. The vagueness of the term "alcoholism" is stressed, and it is pointed out that drinking to excess may occur in at least twenty-eight separate conditions. Some alcoholics, the authors admit frankly, can not be helped, while on the other hand they recognize such a group as the "normal" drinker. The abnormal drinker is defined as: "The man who cannot face reality without alcohol and whose adequate adjustment to reality is impossible as long as he uses alcohol." (p. 35.)

Under the general heading "The Psychology of Alcoholism" we find such chapters as: "The Identification of the Alcoholic," "Suggested Psychological Mechanisms in Abnormal Drinking," "Alcohol and Sex" and "The Alcoholic Breakdown." The authors point out that the attitude of the general public, "which still tends to regard alcoholism solely as an ethical problem to be cured only by punishment or prayer," hampers materially the helpful approach of the physician to the alcohol problem. They go on to say (pp. 128, 129):

> In a sense, alcoholics are still, too often, as badly treated as were the insane hundreds of years ago, when their symptoms were thought to be due to demoniacal possession. It is true that there is no physical inhumanity, but ignorant and clumsy methods too often destroy the very potential in the alcoholic patient that might have been accessible, had this problem, like the neurotic breakdown, been understood by the public as a problem in abnormal psychology.

As for treatment, three fundamental attitudes of mind are pointed out as necessary for success in dealing with the alcoholic:

> 1. The individual must be convinced *from his own experience* that his drinking is so abnormal (of a quality distinct from normal indulgence) that it constitutes an entirely undesirable and impossible way of living.
>
> 2. He must be absolutely sincere in his desire to learn how to stop drinking *once and for all,* regardless of his opinion of his ability to do so.
>
> 3. He must be willing to make a supreme effort to practice *daily, over a long period of time,* and with as much interest and vigor as he is capable, the methods which have proved

[1] *Alcohol One Man's Meat*— By Edward A. Strecker and Francis T. Chambers, Jr. xvi + 230 pp. $2.50. The Macmillan Company.

to be successful in the elimination of destructive habits. (Pp. 190, 191.)

Following the prerequisite recognition by the patient that he is abnormal, an attempt is made to bring him to a more realistic facing of reality and to the keeping of a definite schedule. Frequent consultations with the psychiatrist are held, and it is estimated that about one hundred hours of such conferences are likely to be necessary for the optimum results. Attention is given not only to re-education, the development of a conditioned reflex with regard to alcohol, and self-understanding on the part of the patient, but also, particularly, to nutrition, exercise and diversion. The authors do not advise institutional care, at least as essential, although it is recognized that in some cases it is preferable. The rules which the authors lay down are principally the following four:

1. An understanding on the part of the patient of the seriousness of the condition, and the development of a desire to take the treatment.
2. There must be abstinence from alcohol during the period of treatment.
3. The patient must be entirely frank and honest in all his dealings with the therapist.
4. In the event of a relapse, the patient must notify the therapist, or see that he is notified as soon as possible. (P. 213.)

The volume is practical, progressive and sound. It represents an unemotional, scientific approach to a problem which is wide-spread in frequency and ramifications. The reading of the volume is recommended to all who have alcoholic friends, and indeed to all intelligent and open-minded citizens.

WINFRED OVERHOLSER
SAINT ELIZABETHS HOSPITAL,
WASHINGTON, D. C.

THE GOLDEN PLOVER AND OTHER BIRDS[1]

THIS profusely illustrated work is the second volume of American bird biographies collected in book form from magazine articles by the author. As is well known, in the series of articles originally appearing in the magazine *Bird Lore*, the author writes as if he were the bird telling its own tale, the whole being done in the first person. These stories have had a deservedly wide appeal in their original form and should continue to serve their large and growing audience in their present collected format. While addressed primarily to school children and amateur bird students, they contain much valuable material, not so much in the way of particular observations as in the summing up of long and intimate experience based on many such observations and are, therefore, of interest to the more advanced student as well. For example, it seems simple enough, in the account of the double-crested cormorant (p. 270) for the bird to say of the related species, the common cormorant, ". . . he hasn't half the sense that I have. He hasn't even learned the meaning of a gun. . . .," but obviously a good deal of observation is here summed up. Similarly, the "bird's-eye view" of the southward migration of the golden plover (pp. 12–13) could not have been written if the author had not had a large experience and consequent insight into "personality" of the species.

The large number of photographs illustrating the text is a notable series of observational facts, even independent of the text. The colored plates (representing golden plover, cardinal, indigo bunting, crested flycatcher, meadowlark, cedar waxwing and red-winged blackbird) are less successful, as the colors have not been well reproduced in some cases (especially the cardinal, indigo bunting and the golden plover chicks) and all have a slightly hazy look that is not an advantage to them. At the end of the book are "Questions on the Life Histories of North American Birds," the answers to which are to be found in the autobiographies. There is no index, but this is hardly a lack in a book of this sort.

H. FRIEDMANN

[1] *The Golden Plover and Other Birds*. By A. A. Allen. Illustrated. xiii + 324 pp. $3.00. Comstock. Second Series.

THE HEAVENS AGAIN[1]

THE great success of the Hayden Planetarium, in New York, and of *The Sky*, its splendid popular magazine, have now been supplemented by a popular book on astronomy by two of its assistant curators. Astronomy remains perennially the science in which there is greatest popular interest, whether measured by amateur societies, attendance at lectures or the publication of popular books. In Pittsburgh alone there are about 100 telescopes that have been constructed and are being used by amateurs, and a number of other cities have comparable records.

As might be expected from its title and the positions of its authors, the book under consideration has been written for the lay public. It contains two chapters on the beginnings of astronomy, general discussion of astronomical instruments and a good popular description of the solar system. The more difficult problems connected with the explorations of the universe beyond the limits of the solar system are discussed more briefly. The book is evidently designed for the intelligent reader who has at the best a limited knowledge of astronomy.

Readers of this book will enjoy its clear and straightforward style and its excellent illustrations, though they are not as abundant as in many other books on popular astronomy. The experienced astronomer will feel perhaps that the authors have not been as cautious as they should have been in reporting speculations about conditions on Venus and Mars, and especially in interpreting the inferences that may be drawn from the theory of relativity about the origin, nature and destiny of the universe.

F. R. MOULTON

CONTROLLING "INDOOR WEATHER"[1]

MR. FULLER has prepared this book on air conditioning for readers who "have not had the advantage of higher mathematical training." The subject is a highly technical one, but the author has presented his material very clearly without using technical phraseology; the book is well fitted to the needs of those young men, without a specialized training in engineering, who are concerned with the selection and operation of equipment used for air conditioning.

The arrangement of the material is good, and every important division of the field is considered. The topics covered and their order are: the properties of air, load calculations, duct design and air distribution, registers and grilles, heating and humidifying, fans, cooling coils and air washers, refrigeration and refrigerating equipment, well water and ice cooling, evaporative condensers and cooling towers, unit coolers, controls, air cleaning and codes and ordinances.

There is an excellent chapter on fans and fan performance that is typical. After studying this clear explanation of the fan laws and characteristics of the combined fan and duct system, the reader is better qualified to select a fan for a given duty. The book will not be widely used as a college text, and there is little material for the designer or for the engineer interested in the thermodynamic processes of air conditioning. As stated in the preface, however, the book is not intended for such readers. The method of presentation is distinctly original, and there are very few references to other books or to articles in technical journals. An interesting innovation is the inclusion of a chapter on codes and ordinances that affect the installation of air-conditioning equipment.

Most of the illustrations were supplied by the manufacturers of air-conditioning and refrigerating apparatus. A copy of the Bulkeley psychrometric chart and a pressure-heat content chart for dichlorodifluoromethane (freon 12) are included.

C. O. MACKEY

[1] *The Story of Astronomy.* By A. Draper and M. Lockwood. Illustrated. xi + 394 pp. $3.00. The Dial Press.

[1] *Air Conditioning.* By C. A. Fuller. Illustrated. ix + 577 pp. $4.00. Henley.

THE PROGRESS OF SCIENCE

SCIENCE AND THE NEW YORK WORLD'S FAIR

THE presentation of science at the New York World's Fair differs radically from the purpose and method of previous fairs. The theme of the fair, "Building the World of To-morrow," expresses a great social purpose which is subtly effective. It runs through all the design and is never quite hidden in the glamour, excitement and entertainment features. It assumes that all the instruments are at hand for building a better world and that the public, detached from its every-day affairs, can achieve a broad, forward-looking point of view and, through the agency of the fair, become more aware that modernity goes infinitely deeper than the mere use of to-day's devices and gadgets. Revelations in city planning, in art, in social conditions here and abroad and in the content of modern life will be effective. In all this it is recognized that the most important force in making this new world is science.

In accord with this theme, science is presented throughout as a powerful social force. There is no effort to teach the facts or principles of any of the sciences. On the other hand, the responsibility of science in creating our present world is repeatedly stressed, with less emphasis on the economic and industrial applications of science than on the broader social consequences in community life, in the home, in leisure, habits and morals. "Science to-day," said Grover A. Whalen, president of the Fair Corporation, recently, "can not be confined in a museum and is not the concern of specialists only. It is a part of the very air we breathe. As in daily life we meet the effects of science at every turn, so in the fair science will be found in every presentation of what people do, and has its part to play in almost every building on the grounds."

The responsibility for the portrayal of in the hands of the Advisory Committee under the chairmanship of Professor Albert Einstein, including such eminent scientists as Dr. Frank B. Jewett, president of the Bell Telephone Laboratories, Mr. Gano Dunn, president of the J. G. White Engineering Corporation, and Dr. K. T. Compton, president of the Massachusetts Institute of Technology. Mr. Maurice Holland has served as chairman of the Committee on Scientific Motion Pictures and Mr. Wayne M. Faunce as chairman of the Sub-committee on the Use of Cosmic Rays in the opening ceremonies. Mr. George Sakier is the designer of the central exhibit in science and education.

According to Dr. Gerald Wendt, director of science and education on the World's Fair staff, there are three major aspects of science at the fair. Of these the broadest and most important is the pervasive role of science as a social force. This is portrayed primarily in the theme exhibit within the perisphere and in the half dozen colossal exhibits sponsored by the Fair Corporation. These latter are devoted to the major areas into which the fair is divided, namely: Community Interests, Production and Distribution, Transportation, Communication, Food and Nutrition, and Medicine and Health. Each of these presents major aspects of American life, and science is inherent in each of them.

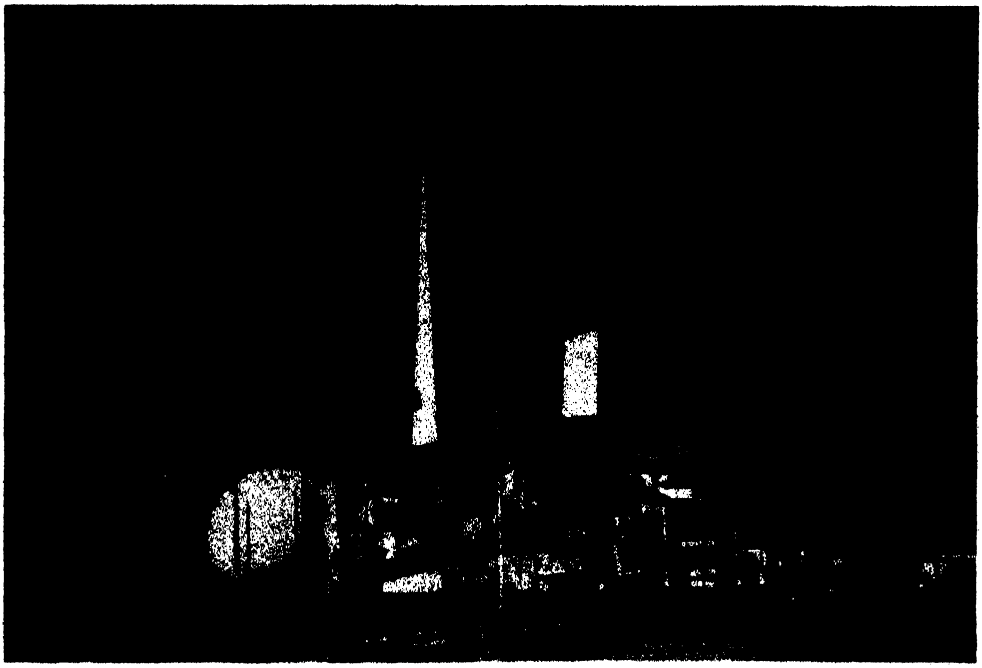
The exhibit in Community Interests may be taken as an example. It brings to a focus the area of the fair that comprises the exhibits in building materials, home furnishings, textiles and cosmetics, "the Town of To-morrow" and the exhibit of contemporary American art. At one side of the hall are shown the living conditions of 1789 with the family as a unit, both social and economic, and with all members working from dawn to dark. They live in almost complete economic independence, but with little leisure or

SYMBOLIC STRUCTURES AND THE GLASS TOWER

WHICH SOARS ABOVE THE GLASS BUILDING. THE LATTER CONTAINS EXHIBITS OF THREE MANUFACTURERS OF GLASS. ARCHITECTURALLY, THE BUILDING DEMONSTRATES MANY INTERESTING USES OF GLASS. BY NIGHT THE TOWER IS ILLUMINATED WITH BLUE LIGHT FROM INSIDE. AT THE LEFT IS A VIEW OF THE TRYLON AND PERISPHERE SEEN OVER THE ROOF OF THE METALS BUILDING

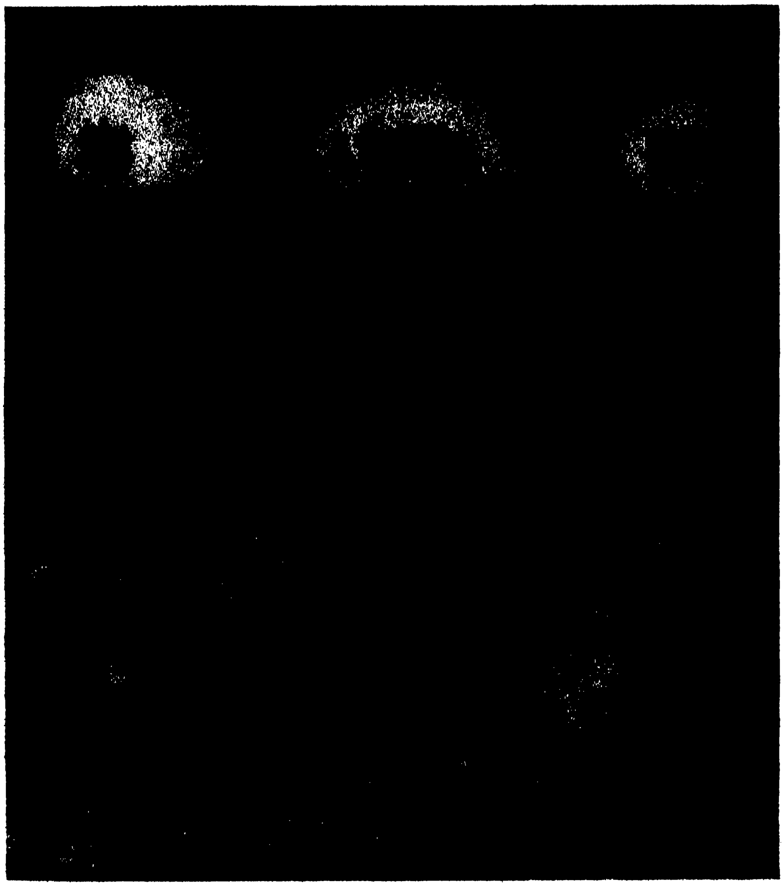
freedom for personal life. The other side contrasts the urban life of to-day, with the housewife dependent on innumerable community services and organizations, but with ample leisure and with every member of the family free from former restraints and compulsions. In the remainder of the exhibit this change is attributed to two streams of invention—one technical and the other social—whereby American life has been enriched and revolutionized. The contribution of science and its applications to this great change is stressed throughout. In a similar manner the effect of science on society through the development of communication, transportation, etc., are memorably displayed.

The second major division of science at the fair, and probably the most impressive, is in the scores of industrial exhibits. It is not possible to select for brief special mention exhibits of any few corporations. Two features are characteristic of practically all the major industries. First, the purpose is broadly in the field of public relations rather than in the promotion of products. Second, their dependence on science and research is the dominant theme. There are numberless displays of research results and research processes. There are statues and mural paintings showing the spirit of science and the pervasiveness of research. There are lectures, motion pictures and demonstrations of scientific principles and of new facts that have resulted in important industrial and commercial developments. There are dioramas envisaging the future of farm, home and factory that may result from recent advances in science. All the sciences are thus represented, though chemistry and physics predominate in this industrial field.



THE TRYLON AND PERISPHERE FROM THE "BRIDGE OF WINGS"
AT THE RIGHT IS THE HALL OF PHARMACY, AS IS INDICATED BY THE EXTREMELY MODERN MURAL BY WILLIAM DE KOONING.

There remains a third aspect in this great portrayal of science, and this is the most unique. The American Association



THEME EXHIBIT OF NEW YORK WORLD'S FAIR

ARTISTS' SKETCH OF THE INTERIOR OF THE 200-FOOT PERISPHERE AT THE THEME CENTER OF THE EXPOSITION CONTAINING AN EXHIBIT BY HENRY DREYFUSS SUMMING UP THE FAIR'S THEME, "BUILDING THE WORLD OF TOMORROW." VISITORS STANDING ON TWO PLATFORMS SUSPENDED IN SPACE AND REVOLVING IN OPPOSITE DIRECTIONS ARE SHOWN GAZING DOWN ON "DEMOCRACITY," THE PLANNED AND INTEGRATED COMMUNITY OF TO-MORROW. THE TIME IS NIGHT. THE SKY OVERHEAD IS ABLAZE WITH CONSTELLATIONS, AND IN THE DISTANCE GLEAM THE LIGHTS OF THE INDUSTRIAL SATELLITE TOWNS SPOTTED AROUND THE NUCLEAR CITY. FROM THE HEAVENS MAY BE SEEN APPEARING THREE OF THE TEN MARCHING GROUPS OF WORKERS, EACH 100 STRONG AND SINGING AS THEY MARCH, SYMBOLS OF THE INTERDEPENDENCE OF MAN AND OF THE COOPERATION BY MEANS OF WHICH SUCH A CITY AS LIES BELOW CAN BE BUILT. THE DRAWING IS BY THEODORE KAUTSKY.

for Adult Education, under the direction of Mr. Morse A. Cartwright, is sponsoring a central exhibit in which science and education are closely joined and which answers the fundamental question as to what science really is. In effect it takes for granted that science is the outstanding achievement of the human race and reveals the secret of its success. This is, of course, the "scientific method."

As the visitor enters the hall he stands in a large rotunda before a beautiful, rather abstract, model of an airplane poised in flight. Human flight is shown as a symbol of man's eternal quest for freedom and power, as an example of the sublime achievements of science and also as a challenge to education—a challenge to the human race to use its vast new powers for the welfare and happiness of the entire race. The plane is supported on a broad pillar with luminous circular pan-

els representing fourteen different sciences upon which human flight depends. These range from geology and astronomy through the more obvious elements of physical science to physiology and psychology. The moral is plain, namely, that human flight depends on vast, painstaking and pure research by thousands of workers in many lands and over many centuries. Surrounding the transparent and abstract conceptions of the fourteen sciences are scenes of industry and engineering, *i.e.*, the applied sciences.

As the visitor then passes into the main hall he faces a massive but simple exposition of the scientific method of thought. First, there are seven great panels in full color, showing observation, gathering, testing and proving of facts. They show the extent to which scientists go in securing reliable knowledge. They answer in turn these questions: What is above, beneath, beyond, within? What is matter, life, energy? Here the artist has portrayed such striking scientific scenes as the ascent into the stratosphere and the descent to the depths of the sea, the search into the remote heavens and into the interior of the atom, the analysis of matter, the mastery of energy and the mystery of life.

From these scenes paths of light lead to an enormous and luminous reservoir of facts and organized knowledge. From it three facts are drawn to exemplify scientific thought. They are the discovery of x-rays by Roentgen, the discovery of radium by the Curies and the isolation of the electron by Millikan. From these Lord Rutherford conceives the idea of the nuclear atom. His experiment in the scattering of alpha-rays by thin metallic foils is portrayed, and his necessary conclusion that the atom is indeed composed of a dense central nucleus surrounded by an electron pattern. This conclusion in turn reverts to the reservoir of science as a new fact and a new principle for the interconnection and organization of many other facts. The nuclear atom also, however, leads to industrial applications of primary importance and these in turn to radical changes in human living, as is shown in a dramatic group assembled in the living room of the American home. The exhibit thus tells in its simplest form the story of an inspired idea, based on established facts, thoroughly tested in the laboratory and resulting in a conclusion which is accepted without prejudice and without emotion to bring large consequences in science, industry and society.

"SPEED" BY JOSEPH RENIER

DOMINATING THE COURT OF COMMUNICATIONS, WHICH EXTENDS FROM THE PERISPHERE AND TRYLON TO THE COMMUNICATIONS BUILDING, IS A FIGURE OF A WOMAN ASTRIDE A WINGED HORSE. THE TITLE OF THE GROUP IS "SPEED" IN THE WORLD OF MODERN COMMUNICATIONS. BASIC MOTIF OF THE GROUP IS THE HORIZONTAL LINE WHICH IS BOTH EXPRESSIVE OF THE THEME AND INDICATIVE OF MODERN DECORATIVE SCULPTURE.

This exhibit in science is closely integrated with the related exhibit in education. As science is the best use of the human intelligence to study and improve the environment of human living, so education is, broadly speaking, the effective adjustment of the individual to his environment. As science is constantly and swiftly changing that environment, education is of necessity a life-long process and, in a democracy, is an essential duty and responsibility of citizenship.

J. M.

THE CENTENNIAL OF PHOTOGRAPHY

WHEN Shakespeare, in the early 1600's, wrote about "holding the mirror up to nature" he had no thought that he was using a phrase which would be applicable, more than two centuries later, to one of the most revolutionary scientific processes in history.

And yet that is exactly what photography did—held the mirror up to nature and captured upon that mirror the images of present events for people of the future to view.

It was just one hundred years ago on January 7, 1839, that Francois Arago, distinguished French savant, stood before the French Academy of Sciences and revealed the process of one Louis Jacques Mande Daguerre, who had succeeded in making permanent images on polished plates. Arago recommended that the Daguerre invention be purchased by the academy and be published for the free use of the entire world. On this date the science of photography had its beginning, in the broadest sense.

Some of the processes involved in photography had been familiar to men for many years. Even the camera, which is usually thought of as part and parcel of photography, had been known for centuries, in the form of the camera obscura. This was a dark chamber in which an image of outside objects was formed by means of light admitted through a small hole. Portable boxes were made with a lens at one end and a screen at the other. These cameras were regularly used by artists in their work, tracing a view directly on transparent paper. But the image was fleeting, and hundreds of people tried to discover some means of automatically and permanently recording a picture.

Since 1727 it had been known that the action of light on silver salts caused them to turn dark. This was the discovery of Johann Heinrich Schulze, a German. But there was not yet an effective combination of the image-forming camera and the image-capturing chemicals.

Many people studied the effect of light upon chemical compounds. Some tried to form images by contact—letting light shine through pictures on glass on to light-sensitive chemicals. Thomas Wedgwood, son of the famous English potter, in collaboration with Sir Humphry Davy, succeeded in making visible images in this manner, but, without a knowledge of the chemical processes of fixing the images, the pictures soon faded. Failure met their efforts to record the image formed by a camera. This was in 1800.

In 1816 Joseph Nicephore Niepce succeeded in obtaining a picture in which the highlights were dark and the shadows light. There was no idea of "positives" and "negatives." For ten years Niepce experimented, and only then succeeded in making a picture with lights and darks in their proper order. It required an exposure of twelve hours.

William Henry Fox Talbot, between 1833 and 1835, managed to secure tiny negative images and to fix them so that they remained upon the paper.

In 1837 Daguerre, who had collaborated with Niepce before his death, made a positive picture on a metal plate, the first Daguerreotype. He tried to interest people in his process, but nobody would give him financial support. No attention was paid to it by people who could help. Few heard of it. Most of those who did thought it was a hoax.

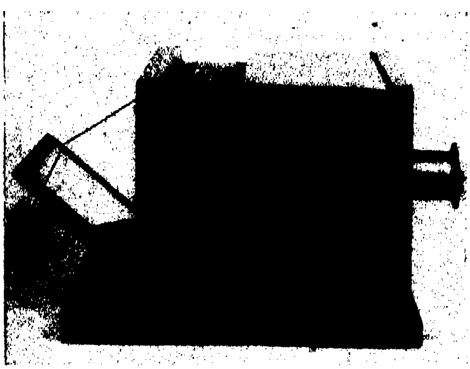
Arago's address before the French Academy of Sciences just a century ago changed all that. Photography was recognized by a group of unimpeachable scientists and, furthermore, the process was given to the world for the benefit of mankind.

The world wanted photography. There soon was ample proof of that. By the middle of the summer of 1839 the French Government had passed the bill giving pensions to Daguerre and the son of

LOUIS JACQUES MANDE DAGUERRE
PHOTOGRAPH OF AN ORIGINAL DAGUERREOTYPE.

FROM AN ORIGINAL DAGUERREOTYPE—NOTRE DAME, PARIS
THIS DAGUERREOTYPE WAS PRESENTED TO THE FRANKLIN INSTITUTE BY THE PHOTOGRAPHIC SOCIETY OF PHILADELPHIA IN 1866. THIS PLATE WAS FIRST SENT BY DAGUERRE TO MR. A. GALLET OF PHILADELPHIA.

Niepce. On August nineteenth, the first public demonstration was given, with enthusiastic crowds surrounding Il Institut de France. Immediately the details of the process were published. There were twenty-six editions and translations into many languages within comparatively few weeks. Everywhere there were enthusiastic experimenters who were eager to make use of the new science of daguerreotypy.

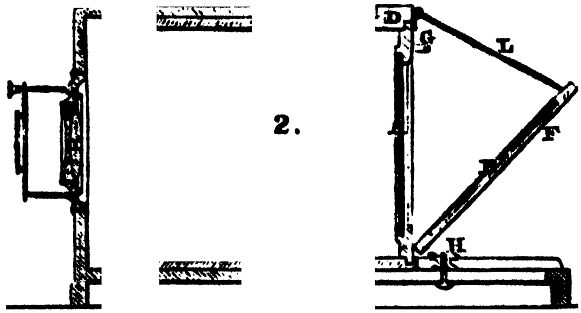


THE BISHOP CAMERA
ON EXHIBITION AT THE FRANKLIN INSTITUTE. THIS CAMERA WAS MADE IN 1839 FROM THE DESIGN PUBLISHED BY DAGUERRE.

In America rumors of the new process had been received for months preceding that date. As soon as the details were released they were sent to this country, reaching here in September. Daguerre's original paper was translated by Professor John F. Frazer, of the University of Pennsylvania. This translation, published in the November, 1839, issue of the *Journal of The Franklin Institute,* was the first publication in America.

Even prior to this publication, however, Joseph Saxton, a member of The Franklin

Observations.—**Before using the box it is necessary to clean the interior, and to turn it upside down so as to shake out of it all the small grains of iodine which may have fallen out of the capsule, taking care not to touch the iodine, which would soil the fingers. The capsule should be covered with a piece of gauze stretched upon a ring; this gauze serves to equalize the evaporation of the iodine, and at the same time to prevent the compression of the air, which results from shutting the box, from causing the particles of the iodine to fly about; some of which might rise to the plate and would make deep stains upon it.**



On this account the box should always be shut very gently, so as not to cause the rising of any dust within it, which might be charged with the vapour of iodine.

DESIGN OF CAMERA PREPARED BY DAGUERRE

AND PART OF THE TRANSLATION OF HIS ORIGINAL ARTICLE ON HIS METHOD OF MAKING PHOTOGRAPHS PUBLISHED IN THE NOVEMBER, 1839, ISSUE OF THE *Journal of the Franklin Institute.*

Institute and an employee of the United States Mint, using information received from an eye-witness of a public demonstration, succeeded in September, 1839, in making a photograph upon a piece of the silver from which the mint stamped coins.

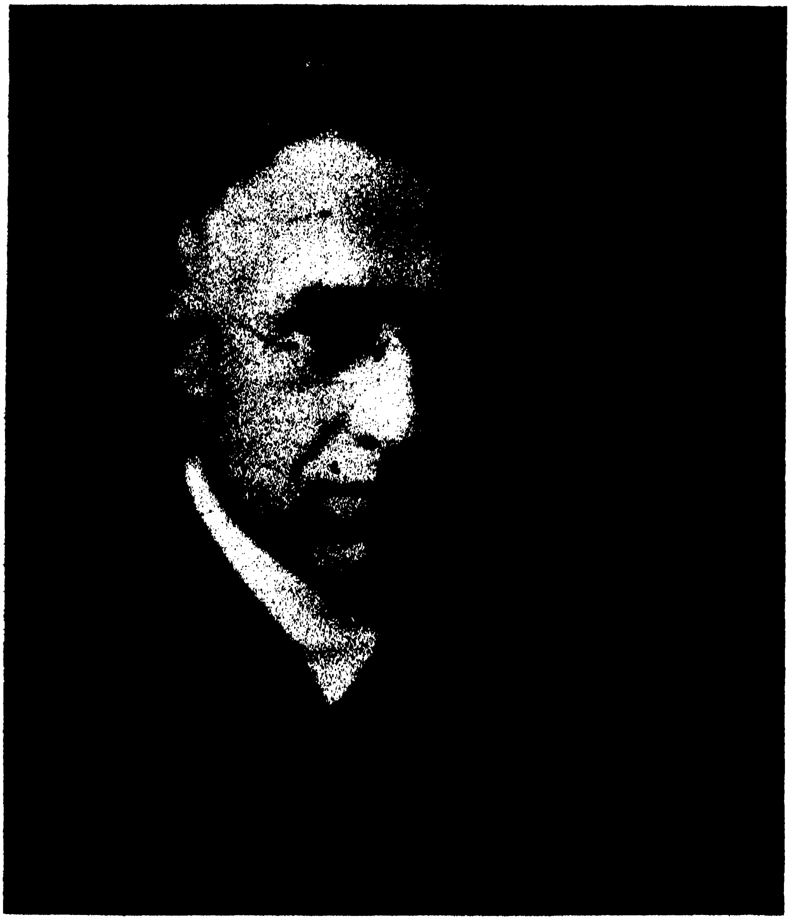
Within a few weeks after the publication of the process, a Philadelphia chemical instrument maker, Joachim Bishop, made three daguerreotype cameras—the first to be manufactured commercially in America. One of them, still in existence, is a prized exhibit in the Photographic Section of The Franklin Institute. To mark the centenary of photography, this camera, the oldest in America, was recently used by Miss Gladys Muller to make some daguerreotypes, using the process described in Daguerre's original paper.

In the days when American enthusiasts were eagerly awaiting every new word of the process of daguerreotypy, it was frequently referred to as the art of imprisoning the sun's rays within a morocco case. From that time, a century ago, to the present day, the camera has had a growing army of experimenters. From the moment that the Daguerre process was presented to the world, for the benefit of mankind, it would seem as though all men joined in furthering the science with their greatest efforts.

SYDNEY L. WRIGHT

AWARD OF THE NICHOLS MEDAL TO PROFESSOR HILDEBRAND

IN recognition of outstanding achievement in physical chemistry, Professor Joel Henry Hildebrand, of the University of California, recently received the William H. Nichols Gold Medal of the New York Section of the American Chemical



PROFESSOR JOEL H. HILDEBRAND

Society at a joint dinner of the section and the Society of Chemical Industry in New York City.

More than 400 scientists united in honoring Professor Hildebrand for "his study of the solubility of non-electrolytes." Presentation of the medal was made by John M. Weiss, chairman of the jury of award. The scientific accomplishments of the medalist, embracing more than thirty years of research on liquid and solid solutions, was described by Professor Henry Eyring, of Princeton University. Professor Herbert S. Harned, of Yale University, spoke on "Joel H. Hildebrand—The Man." Walter W. Winship, chairman of the section, presided.

In the presentation address Mr. Weiss stated:

"Professor Hildebrand is internationally known in the broad field of physical chemistry. More than that, he has been one of our few contemporary real teachers of chemistry. His public service has been of the highest order. His work in chemical warfare has contributed greatly to our national defence, both in the field and in the laboratory. His whole life has been one of service to science and the public weal."

Professor Hildebrand, a native of Camden, N. J., is 57 years of age. He received the bachelor of science and doctor of philosophy degrees from the University of Pennsylvania in 1903 and 1906, respec-

tively, and studied at the University of Berlin for a year. After teaching at the University of Pennsylvania six years, he became assistant professor at the University of California in 1913, rising to full professorship in 1918.

During the World War, Professor Hildebrand was first commissioned captain of the Ordnance Reserve Corps, then major and later lieutenant colonel in the Chemical Warfare Service. As director of the Chemical Warfare Service laboratory at Puteaux, near Paris, and as commanding officer of Hanlon Field, near Chaumont, he played an important role in organizing the American Expeditionary Force Gas Defense School and the experimental field for gas warfare research under practical conditions. For this work he received the Distinguished Service Medal.

He suggested to the U. S. Bureau of Mines the use of a mixture of helium and oxygen in place of air for divers and caisson workers to prevent the dangerous "caisson disease" or "bends." The effectiveness of this artificial atmosphere was recently demonstrated by Max Nohl, engineer, with the collaboration of Dr. Edgar End, physiologist of Marquette University, in increasing the record for deep-sea diving by 100 feet.

Professor Hildebrand is a past president of the American Physical Society, an honorary member of the Chemical Society of Edinburgh, corresponding member of the Physikalisch Medizinische Societat of Erlangen, Germany, and a member of the National Academy of Sciences. He has been councilor-at-large of the American Chemical Society. He is president of the Sierra Club and in 1936 managed the U. S. Olympic Ski Team.

Professor Hildebrand is the thirty-third chemist to receive the Nichols Medal, founded in 1902 "to stimulate original research in chemistry" by the late Dr. William H. Nichols, charter member of the American Chemical Society and leader of the chemical industry in this country.

Members of the 1939 jury of award, in addition to Mr. Weiss, were Professor A. W. Hixson, of Columbia University, Professor William C. MacTavish, of New York University, Dr. D. P. Morgan, Mr. Winship and Dr. Cornelia T. Snell, secretary of the section. A. C. S.

THE VELOCITY OF LIGHT

By a new method Dr. Wilmer C. Anderson, of Harvard University, has measured the velocity of light with a greater accuracy than heretofore attained. The value he obtains for this important physical quantity is 186,264 miles per second. The most precise previous measurements gave 186,271 miles per second, the two results differing by one part in 26,600. The uncertainty in the value for the velocity of light as determined by Dr. Anderson is probably less than one part in 18,000. As precise as his results are, they fall far short of the relative accuracy of several other determinations of physical quantities.

Galileo appears to have been the first to attempt to measure the velocity of light; perhaps he was the first to suspect that light is not transmitted instantaneously. A any rate, he tried to determine the velocity of light by using lantern signals between two mountains, and naturally failed. The first approximate determination of the velocity of light was by Roemer, in 1676, from observations of the times of eclipses of Jupiter's larger satellites. He obtained 192,000 miles per second. Fizeau, in 1849, was the first to measure the speed of light by laboratory methods, obtaining 195,800 miles per second. His method was modified, in 1862, by Foucault, famous for his simple proof of the rotation of the earth by swinging a pendulum. Subsequent work on the problem has been done in

this country, first by Newcomb and Michelson, later by Michelson alone, and finally, until the present experiments by Anderson, by Michelson and his co-workers Pease and Pearson. Their final value for the velocity of light, obtained after Michelson's death in 1931, was 186,271 miles per second.

Dr. Anderson obtained his results by an entirely new experimental means. He caused the intensity of a beam of light to vary periodically in brightness 19,200,000 times per second. Consequently his beam of light had relatively bright and dark portions at intervals of 51.2 feet (186,264 miles, divided by 19,200,000 reduced to feet). If two such beams were united in the same phase, the variations in brightness would be doubled; if in opposite phase, the light would be uniform. By splitting his beam of light into two parts with a half-silvered mirror and sending them over different paths of controllable lengths before reuniting them, Dr. Anderson could bring them together in the same phase or the opposite phase at will. From the difference in lengths of paths to change the beams from the same phase to opposite phase, all measured under laboratory conditions instead of using great distances, he obtained his very accurate results.

All previous methods of measuring the velocity of light required the use of rapidly moving physical parts. Fizeau employed a rotating cogwheel; Foucault, rotating mirrors; and Michelson, in his last experiments, a mirror having 32 sides. There are naturally serious difficulties in maintaining constant speeds of rotation and determining precisely what they are. The speed of light is so enormous that, using these methods, long paths of the reflected beams are necessary in order to get results of high precision. But long paths result in spreading of light and errors due to turbulence of the air. In order to maintain sharp optical images, Michelson and his collaborators, in their final experiment, sent the beam

APPARATUS USED BY DR. ANDERSON IN MEASURING THE VELOCITY OF LIGHT

of light which they used back and forth, by multiple reflections, through a steel pipe from which the air had been pumped. Few persons would undertake the serious problem of making air-tight the joints in a steel pipe a mile long and pumping the air from it. But such daring and industry are characteristic of scientists.

By modulating his beam of light Dr. Anderson avoided at one stroke the difficulties of moving physical parts and very long paths. Instead of using a mile as Michelson did even in his last experiment, and 10 miles including the repeated reflections, the whole optical path required by Dr. Anderson was only a little more than one tenth of a mile. One may inquire why his method was not used long ago. The answer is that he turned to recently developed means of modulating light, and to the photoelectric cell in determining where his reunited beams were in phase. Thus every new addition to science makes possible advances in many directions, and the further science develops the more important additions become. This aspect of the matter is somewhat similar to the old game of making as many words as possible out of a few letters. If a given letter is added to five letters it may make possible the construction of ten new words; if the same letter is added to ten letters it may make possible the construction of 100 new words.

Many persons have wondered why scientists, beginning with Roemer and continuing to Michelson, have devoted so much attention to the velocity of light. There are many reasons why the velocity of light is a physical quantity of very great scientific importance, among which are: (*a*) it is one of the several properties of light from which its nature may yet be determined; its differences in various media are a test of the corpuscular theory versus the undulatory theory of light; it is taken as an absolute constant and the maximum possible velocity in the theory

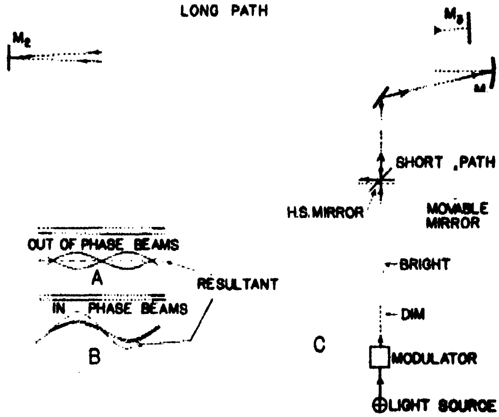
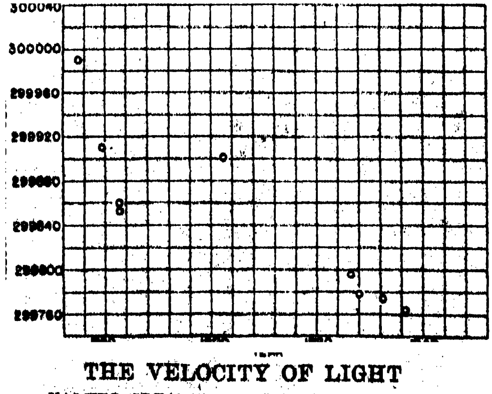


DIAGRAM OF APPARATUS

of relativity, a theory which was initially developed to explain Michelson's failure to find the expected effects on the velocity of light of the earth's (and observer's) motion through the assumed ether.

The question now arises whether the velocity of light, as determined by measurements, will be found constant. If it should not be found constant, it will apparently be necessary to revise the relativity assumption that it is a fundamental constant of the universe. Of course, since a velocity is a distance directed by a time, an observed variation in the velocity of light could be interpreted as a variation in the length used, or in the measurement of time intervals, or in both. Each of these assumptions would raise other questions and make difficult the development



THE VELOCITY OF LIGHT
VALUES OBTAINED AT DIFFERENT DATES.

of consistent and satisfactory theories of all the related phenomena.

All this illustrates Poincaré's thesis that every set of phenomena can be interpreted consistently in various ways, in fact, in infinitely many ways. It is our privilege to choose among the possible interpretations the ones that appear to us most satisfactory, whatever may be the reasons for our choice. If scientists would remember that various equally consistent interpretations of every set of observational data can be made, they would be much less dogmatic than they often are, and their beliefs in a possible ultimate finality of scientific theories would vanish.

F. R. MOULTON

THE GREAT ANTEATER GROUP AT THE FIELD MUSEUM

ONE of the additions to the Hall of American Mammal Habitat groups in the Field Museum of Natural History is an exhibit of the great anteater. This animal, which ranges from southern Mexico to southern Brazil, is one of the queerest of the many queer beasts inhabiting the American tropics. It is peculiar in appearance, in structure and in habits. One of its names is ant bear, perhaps on account of its large size and shaggy coat, but it is not even remotely related to bears. It belongs to that rather anomalous group of mammals called edentates, of which the known extinct species are much more numerous than those now living. It is one of three principal kinds of anteaters in South America and Central America, the other two being the Tamandua and the silky anteater, both smaller and more arboreal in habits.

The bizarre appearance of the great anteater is largely due to its very long and very narrow head. This is so highly specialized that a description of it seems to call for hyperbole, and one is reminded

THE GREAT ANTEATER GROUP

of Mark Twain's famous characterization of the Platte River, in which he said that it was "a mile wide and an inch deep." The anteater's head is actually six times as long as it is wide. In other words, it is longer than that of a very large grizzly bear and scarcely wider than that of a jack-rabbit. The mouth is reduced to very small size, only serving as an opening through which to protrude its long, extensile tongue and draw in its insect food. That such a large animal should be wholly sustained on a diet of ants and termites seems incredible, but this is the case. Although this must be regarded as strong testimony to the abundance of these insects in the countries south of us, it is still stronger as to the efficiency of nature's machine for capturing them in large quantities. The great anteater has sometimes been kept alive successfully in zoological gardens, but it is an expensive pet, for its board bill runs to high figures. To supply it with all the insects it needs reaches a cost rivaling that of the tons of hay for the elephant.

Teeth are unnecessary for an anteater, and they have been entirely eliminated, but the animals are provided with unusually large salivary glands which supply a viscid secretion to assist the effectiveness of the tongue. The long, heavy claws of the front feet are used mainly for tearing open the ant and termite nests, but can be used very effectively when necessary in defense. For this reason the anteater is held in very great respect by local hunters and also by such predaceous animals as the jaguar and the puma, which are usually inclined to give it a wide berth. Many a good hunting hound has been literally disemboweled by a powerful sweep of these claws.

The museum's group was obtained by Colin C. Sanborn during the Marshall Field-South American expedition of 1926. The animals are shown in the light forest or semi-savanna of southwestern Brazil, where the physical conditions are those they prefer. They may also occur about the edges of heavy, humid forests but do not penetrate far into them. The taxidermy is by Julius Friesser and the painted background by Charles A. Corwin.

Wilfred H. Osgood

COMPOSITION OF GASEOUS NEBULAE

Sir William Herschel, 150 years ago, thought that the nebulae are systems of stars so far away that their members could not be seen separately through the telescopes then in existence. But he looked forward hopefully to a time when better telescopes would resolve them into individual stars. Herschel's ideas were proved to be erroneous about a century later when it was proved with the spectroscope that the light received from the nebulae, at least in many cases, is radiated by great masses of gas. The spectral lines showed that the radiating elements are such light gases as hydrogen, helium, nitrogen and oxygen.

Naturally astronomers speculated on the origin of the gaseous nebulae and their future evolution. The idea prevailed widely that they are world-stuff in an early stage of evolution, and that in the course of enormous intervals of time they will concentrate into stars. It was supposed that in some unknown way such heavier elements (iron, nickel, copper, etc.) as are found in the sun would evolve.

At the meeting of the National Academy of Sciences held in Washington on April 24 and 25, Dr. I. S. Bowen, of the California Institute of Technology, announced that the gaseous nebulae contain the heavier metallic elements found in the sun and about in the same proportions. These elements were now found earlier, because under the conditions existing in the gaseous nebulae their spectral lines

(the wave-length which they radiate) are predominantly different from those in the sun.

Of what especial interest is this discovery of Dr. Bowen? It will bear directly upon every theory of the evolution of matter in the immense intervals of the cosmic processes. Perhaps the theory that nebulae are world-stuff in an early stage of evolution will have to be abandoned. Possibly the stars and the nebulae are only different phases in an evolutionary cycle transcending anything heretofore contemplated. F. R. M.

A NEW EXPLANATION OF SUBMARINE CANYONS

Dr. Douglas Johnson, of Columbia University, presented before the April meeting of the National Academy of Sciences a new hypothesis respecting the origin of the amazing submarine canyons that have been found during recent years off both the Atlantic and Pacific coasts of this country and in other parts of the world. These canyons are deep, often with very steep walls, and resemble canyons produced by swiftly flowing, deep-cutting rivers. Indeed, in some cases they are comparable to the Grand Canyon of the Colorado.

A natural explanation of the submarine canyons is that they were formed when the coast lines were higher than at present, and in some cases they certainly have been. But the changes in level required by this theory are not easily reconcilable with other known facts. Other suggested explanations encounter equal difficulties.

Dr. Johnson recalls the fact that water expelled under artesian pressure in springs on land often produces marked canyons in relatively short intervals of time. He suggests for consideration the hypothesis that submarine canyons have been produced similarly by water forced up by hydrostatic pressure through consolidating sediments that have been deposited off coast lines. Certainly such pressures and eruptions might take place. The problem is to determine whether they would produce canyons having the characteristics of those that are found in the continental shelves off many coast lines.

F. R. M.

MENTAL BREAKDOWNS IN THE AFRICAN VELD

New evidence for a similarity between the minds of men in darkest Africa and residents in the capital city of the United States was seen when a film taken in a mental hospital of South Africa was shown before an audience of anthropologists in Washington, D. C.

Mental breakdown occurs in the veld as it does in the modern metropolis. And the mentally ill are considered "queer" by their neighbors in primitive society, just as they are in civilization.

Bantu patients coming to the mental hospital in Africa bear evidence of never having taken part in the rites introducing them to mankind. Many have never been taken into the tribes as adults, presumably because it was recognized that they were not acceptable.

Neither had they taken part in the usual social customs of the tribe. Among the Bantus, boys and girls customarily take part in a sort of courtship custom not unlike the old New England custom of "bundling." But Dr. J. B. F. Laubscher, the psychiatrist who filmed these African mental patients, found that many of them had never been able to attain such terms of intimacy with any girl in the tribe.

Those who consider mental breakdown to be the result of the excessive strains of modern civilized life may find food for thought in the faces of the Bantu actors in Dr. Laubscher's real-life film drama. The patients in this far-away African hospital can be matched, case for case, in St. Elizabeths Hospital at Washington, D. C. The similarity was pointed out by Dr. Winfred Overholser.

Majorie Van de Water
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THE GROWTH OF ASIA

By Dr. BAILEY WILLIS

EMERITUS PROFESSOR OF GEOLOGY, STANFORD UNIVERSITY

TRADITION tells us that Mother Earth is a wrinkled old dame, whose once intense, youthful energies are nearly spent. But tradition is ignorant of those facts which have been discovered through research in physics and geology and which demonstrate beyond question that she is really a vigorous young thing, whose actual activities are quite as intense, or perhaps even more so, than during any past age. We observe, for instance, that there are extensive plateaus, which have but recently, in terms of geologic time, been raised to great elevations. We survey great mountain chains and learn from the forms of the valleys carved in them that they are actually in process of being squeezed up. The Alps, the Himalayas, the Cordilleras of North and South America are young, growing structures, manifestations of tremendous forces, even now at work.

"What is the force that lifts mountains?" I once asked an eminent physicist. He reflected. "Too big," said he. Too big for human imagining, and yet, if I mistake not, it resides in the infinitely small. But of that later.

Youth is, perhaps, not the actual stage of Mother Earth's activities; we might better say adolescence, for she has had her full figure as a planet for two thousand million years that we know of, and the formative stages, whatever they were, presumably occupied a similar lapse of time. We have to thank Madame Curie for that approximately definite knowledge of the age of certain rocks, it being determined from the rate of change of uranium into lead; and now that we have that clue, we learn that the crust of the globe is made up of masses which differ widely in age, some being as much as two thousand million years old, while others date from periods that are not more than twenty millions back of the present. Here, again, our traditional concepts are contradicted. We have long thought of the crust of the globe as having formed by the cooling of a molten sphere, that is at once; any later eruptions were considered minor effects of residual, failing energies of the cooling body. But now we have to recognize that the processes of eruption of the so-called igneous, *i.e.*, melted and crystallized, rocks have been persistently active, not continuously or uniformly, but from time to time, and apparently with but little, if any, diminution of intensity.

This means sustained energy, gradually dissipated by loss of heat, or it means that there is a vast store of energy, from which minor amounts are from time to time released in such a way as to melt bodies of solid rock and to cause them to rise toward the surface,

where they appear as intrusive masses of granite or as extensive lava flows of basalt. Estimates of original heat indicate conclusively that it could not have sufficed to maintain the observed activity during two billion years, and we are led to follow the astronomers, who find the source of the sun's heat and of the internal energy of the stars in atomic changes. The globe contains radioactive minerals, and in them we may reasonably seek the cause of Mother Earth's repeated rejuvenescence.

The old geology, based upon that limited science of physics which led Lord Kelvin to judge that it was more than twenty and less than forty million years ago that the earth solidified, has now to revise many an ancient and once generally accepted theory in order to adjust its hypotheses to the enormous potencies that reside in the atoms. To illustrate the change which is being required in our ideas as geologists, we may review contributions to our knowledge of the geology of Asia, going back a little more than seventy-five years and considering only a few of the eminent scientists who have explored the great continent. As it happens, the writer need name only two among those with whom he has happily been associated.

Raphael Pumpelly in 1863–64 and Ferdinand von Richthofen during the four years 1868–72 opened the records of the geology of China by explorations in that half-a-continent which had been practically closed to Europeans since the expulsion of the Jesuits more than 200 years before. It is interesting to compare and contrast the two. Both were intrepid explorers, equally bold in planning their journeys, equally broad in their interests in the Chinese as a people and in China as a land. But they differed radically in their ultimate purposes. Pumpelly sought knowledge for knowledge's sake. He wished to know the unknown, but he felt no compelling to inform others. Generous of spirit, he gave as freely of his thoughts as of things material and always with the desire that others should derive the greatest possible benefit from the intellectual largesse he scattered liberally. With von Richthofen it was otherwise. He became the guardian of that which he discovered. He felt responsible for it. What he acquired he cultivated. He shared it personally only with those whom he deemed worthy. The difference between the two was temperamental and also racial. Pumpelly, whom the Chinese called the Redbearded Devil, derived from the roving Vikings, happiest when driving carefree down the winds of opportunity, beyond the ken of men. Richthofen was a modern Roman, obedient to the system in which he had been drilled and of which he knew himself to be a leading exponent. They typified the spirits of America and Prussia.

The geologic principles which guided the researches of these two explorers were, however, the same. Their geology was static, in the sense that what was had long been so and had remained unchanged. They recognized the ancient foundations of the continent, the metamorphic and granitic rocks, they identified certain marine limestones and other strata as belonging to one or another geologic age, according to the fossils; they thus began to trace the design of the mosaic of the land, much as an archeologist may study that of a Roman pavement. Many others have followed them, surveying and making maps; British, German, French, Russian, American, Chinese and Japanese have brought their contributions, and the last named have published a complete geologic map of Eastern Asia.

The mosaic of Asia, like that of other continents, has been built up by three

processes; the one, originating within the earth, has contributed the igneous, molten rocks, which have cooled and solidified just below or on the surface; the second is that which by agency of the waters of the seas or atmosphere spreads sediments, forming extensive beds of sandstone, mudrock, or limestone; the third adds nothing to the materials, but it introduces a modified pattern, by compressing the layers so that they become folded, and by shearing through and displacing the more massive bodies of the igneous and metamorphic rocks. The effect of squeezing is generally most apparent in long, narrow belts, each one of which becomes a mountain range or chain, a curving wrinkle on the face of Mother Earth, as if she smiled. In the pattern of Asia the mountain arcs are arranged like garlands, stretched along the southern margin of the Siberian plateau or pendant from one another in ever-widening design toward the south, but diverging east and west. The outermost on the south is the stupendous sweep of the Himalaya chain, skirting the high plateau of Tibet.

The mountain chains of Asia are indeed stupendous. From the days of Marco Polo down to yesterday, when Mallory and Irvine climbed to death on Everest, and long before Marco, back to the time when the first lama aspired to the snows, they have drawn men to the heights, and so also they have dominated the research of scientific explorers. As the slow camel train plodded across the interminable desert flats, the eye sought the distant peaks and the mind dwelt upon the secret of their being. The devout thought of God; the geologist pondered the power and the laws of nature. And so the sands, the rocks beneath the camel's feet were passed over, unnoticed. And yet in them is hidden the record of the growth of the continent. Let us seek to read it.

The rock of the wide spaces is largely granite. Granite, we learn from elastic earthquake vibrations, is the rock that has built up continents. A continent, indeed, may be described as a thin layer of granite floating in solid basalt, the latter being the more common in the earth's outer crust. The layer varies in thickness, from a very few miles to as much as twenty or more in the roots. It is like scum on a melting pot, and the long accepted idea has been that it did originate in and cooled on the surface of the primeval globe. Although we now know that there are relatively very young granites, it is still held by conservative thinkers that they are comparatively very small in volume and perhaps different in origin. That remains to be seen, but it must be admitted that the older masses, now exposed to our view, are much more extensive than the latter ones. It does not necessarily follow, however, that the latter originated differently. The processes in the deep-seated laboratory of the globe appear neither to have changed in method nor intensity and, if molten basalt or other mineral melt can go through a process of gestation, by which its constituents separate to form granite and other kinds of igneous rock, in the earth as in our experiments, the reactions should be the same to-day as always, in kind even though not in volume.

In northern Siberia, in the Gobi Desert, in the plateau of Tibet and in Peninsula India geologists identify very, very ancient granites. Those of India, whose age has been determined by analysis, range from 1,500 million to but 600 million years, and the others are of similarly great antiquity. In eastern China, in the Province of Shantung, and in northern Korea there is also a body of very old, Archean rocks, including granite. The holy mountain, Taishan, is carved from them and the name, Taishan

formation, has been given to all similar masses in Asia.

These granite bodies are the nuclei of the continent. They are of sub-continental dimensions, several hundred miles across, but they are also complex and can best be described as made up of a number of intrusive bodies in a matrix of still older rocks. We find no beginning, only something older than any other record. Large as they are, these nuclei cover only a fraction of the entire land surface of Asia. Between them are wide strips or zones, occupied by younger rocks, which are in lesser part igneous, in larger part sediments. Where the sediments are marine, we know that the waters of the sea flowed between the nucleal lands. As of all ancient history our knowledge of the record is but fragmentary, yet we may say that this was not our Asia, not the continent. It was a group of large, sub-continental islands; and it had that character during many hundred million years.

Without attempting to be exact as to dates, we may say that this Asiatic archipelago, comprising India on the south and Siberia on the north, developed during that most ancient era, the Archean, and during much of the succeeding era, the Proterozoic. Perhaps we should assign to its latest stages the intrusion of a body of granite, known as the Sangkan gneiss, which pushed up in Mongolia, in the region about Kalgan, northwest of Peking, toward the close of the Proterozoic; or we may extend this prolonged series of uptrusions to include one that appeared widely in Mongolia at the very close of the Proterozoic era or in early Paleozoic time, four or five hundred million years ago, when the trilobites reigned in adjacent seas.

Thus, during a thousand million years which we can recognize and during an unknown, preceding era, probably of many hundred millions, northern Asia was being built up on more or less independent granite nuclei and cemented by minor intrusions; while sediments, deposited in the inter-nucleal spaces, covered the basement rocks and became folded into the complex. The area of consolidated, continental land, after the latest Proterozoic intrusion, apparently constituted all Asia as we know it north of the fortieth parallel. But Tibet and Peninsula India remained separate.

During the succeeding two hundred million years of the Paleozoic era the central zone, between Mongolia and Tibet, was for long periods submerged beneath marine waters; it appears at times to have been dry land, as though the bosom of the growing continent rose and fell. But the wide passage between Tibet and India, now occupied by the Himalayas and the Ganges, was traversed by ocean currents, flowing steadily westward, over the present site of the Alps and Pyrenees to the Atlantic. Geologists know that strait, which crossed Eurasia from the Pacific to the Atlantic, as the Tethys. It continued open for another one hundred and fifty million years, down to the beginning of so-called Tertiary time, some fifty or sixty million years ago. It is since that latter date that the great elevations, the mountain chains, such as the Himalayas and Alps, and the high plateaus, such as Tibet, have been thrust up and the continent of Eurasia united from north to south.

But before that uplift of plateaus and upthrust of plateaus occurred, there were manifestations of the internal energy of the earth in the primary form, that of the intrusion of molten granite bodies into the outer crust. As they are now exposed they are relatively small, as compared with the ancient ones, but their wide-spread distribution throughout southeastern Asia suggests an active condition beneath that region in general. These late intrusions first reached sedi-

mentary rocks, whose age is known by fossils, about a hundred million years ago, during the latter part of the Mesozoic era, and they continued to rise during some fifty million years, continuing into the Tertiary. In the island of Hongkong, for instance, there is granite of early Tertiary age.

These young granites have been identified all along the arc of the Himalayas, the Malay Peninsula, Sumatra and Borneo. The young granites are known also, thanks to our able Chinese colleagues, in many localities throughout southeastern China. Unfortunately their surveys have been interrupted and the latest observations remain unpublished. Similar young intrusions, though not always granitic, constitute the foundations of the Dutch East Indies, the Philippines and of the Japanese islands. All the continent lying east, southwest and south of central China, clear out to the marginal island areas, has been filled in by these relatively very recent eruptions to constitute the land of Asia as we know it. Intense activity of the superficial, but deep-rooted, volcanic type is characteristic of the outer edges, toward which the continent has grown. There is every reason to think that it is still growing.

May we not liken the growth of a continent to that of a vast forest? In the earth lie the seeds of granite bodies; being vivified, they become molten, and thrust up, like tree trunks, till their upper branches spread to a wide expanse. Younger growths assemble around the ancient trunk and the crown is widened. There is an analogy, but what is the seed of the molten mass? From what source comes the energy to melt it?

Before this question our older geology stalled. The terrestrial forces, with which to animate old Mother Earth in our speculations, were limited to the attraction of gravity and the residual heat of the hypothetical, incandescent sphere. But gravity is conservative, unless disturbed, and heat is dissipated by conduction, radiation and eruptions. Two billion years! That is a long time to stay hot in cold space, even under the blanket of the atmosphere. Mother Earth should be chilled, stark; like the moon. Why isn't she?

For the past thirty years physics, the science upon which geology depends for its knowledge of energy, has held out the idea that even in the globe, as in the stars, the potential forces of atoms might be released. Radioactive minerals were found and it was discovered that they generate heat. They generate it very slowly, to be sure, but constantly, inexorably, inevitably. Analyses of rocks showed that potent minerals of this kind occur in the crust of the earth in the proportion of about one part in a billion parts. That seems insignificant, but calculation showed that if radioactive minerals were *uniformly* distributed throughout the whole globe in that proportion, it must have melted before the lapse of two thousand million years. The earth is at least that old, but it is not melted. Thus the mathematicians reasoned themselves to a standstill.

But why assume a uniform distribution of any mineral, either for the whole globe or for any particular shell, near the surface or at any chosen depth? The ores of uranium and thorium, the principal radioactive minerals, resemble those of gold, for instance. However convenient it might be according to certain ideals if gold were uniformly distributed, it is not. Let us look at the realities. The earth is an extremely heterogeneous body, especially in detail. The uniform occurrence of any minor constituent is unknown and very improbable. Radioactive minerals occur only as one of the very rare constituents. What if they are and have been quite lacking in some parts, sparsely present

in others, and more concentrated here and there in the huge mass of the globe. The relative richness or poverty in heat generators would determine the rate of production of heat, and rocks which perhaps had cooled, or had never been anything but solid, would melt accordingly, sooner or later.

We may visualize the conditions of melting. In a mass situated at some depth, fifty, a hundred, a thousand miles below the surface, where the temperature of the solid shell is near the melting point, the relatively inert minerals are assumed to be associated with crystals of persistent heat generators. Melting will occur around each active crystal according to its product of heat energy. As the diameter of the effect grows the melt will come into contact with others. The molten mass will enlarge by coalescence. In time, in long time, there will result a body of some size, consisting of the molten rock, of refractory, unmelted crystals, and possibly of unmelted, residual lumps. It will grow *in situ* until it reaches such a size (one to several million cubic miles in volume) that it becomes unstable and must rise because it is squeezed up by the pressure of the walls, which at such depths are overloaded. Its ascent, though aided by the heat of hot gases and currents accumulated toward the top, must be excessively slow, but will continue until the mass reaches a level at which the escape of heat by diffusion, conduction and outflow of lavas exceeds the increment from any contained heat generators. Then the mass will cool and become fixed. But the radioactive heat generators remain and the body will heat up again in the course of a hundred million years or so, unless it is so near the surface that the energy escapes as fast as it is generated. It then becomes a bit of the crust of the earth, which is made up of flattish discs of granitic and basaltic rocks.

Thus I conceive the development of the continent of Asia to have gone on through the ages. I have seen every stage of it, from remotest antiquity to the present; I have seen it as I followed in the footsteps of Pumpelly and von Richthofen, as I motored through India, flew over the Philippines, or journeyed with courteous Japanese colleagues in their volcanic isles; yes, I have seen it —in my mind. But who knows how much is obscured by the mists of time or hidden in the depths of the earth or distorted by my misreading of the record? I can not say, but Mother Earth continues to smile at me with her wrinkled old visage. To explain the wrinkles is another, but intimately related story.

APPLICATIONS OF SCIENCE TO THE METALLURGICAL INDUSTRY

By Dr. JOHN JOHNSTON

DIRECTOR OF RESEARCH, UNITED STATES STEEL CORPORATION

METALLURGY is one of the most ancient arts, and its development has had, and is likely to continue to exert, a decisive influence upon the kind of civilization in which we live. Without metals in considerable quantities we should still be little more than savages in our mode of life; the abundance of their use, which is determined by their real cost, is almost a measure of the standard of living enjoyed by a people. The metallurgical processes in use since time immemorial changed but little, except for a slow increase in the size of units and in the scale of operation, up to about the period in which the steam engine was invented and developed, with the consequent rapid advance in mechanical engineering. In this connection it is interesting to recall that the realization of a practical steam engine was delayed about 20 years because it took Watt that time to make a cylinder in which his piston would move without undue leakage; this is but one of the many examples of the dependence of progress in the industrial arts upon advances in metallurgical knowledge and skill.

The difficulty met by Watt raises a question which I would like to mention, as an illustration of our dependence upon metal tools. How long would it take for a people, reasonably well provided with metallurgical and engineering knowledge but entirely without metal of any kind, set down in an isolated land endowed with all necessary metallurgical raw materials, to develop industry on a scale comparable to that in any of the more highly industrialized countries? My guess is that it would take a far longer time than most people realize, probably half a century or more, even with the intensest application. For the metallurgical art would have to start on the most primitive scale, to produce tools without which the scale of operations could not be enlarged; and this gradual enlargement would proceed very slowly over a period reckoned in years rather than in months. Consider how long it would take them to produce even a crude lathe which would permit of the building of a small steam engine; with a source of power they can proceed on a more rapidly growing scale, and so gradually begin to produce the many shapes and kind of metal articles indispensable to their further progress in the industrial arts. Even at this level of progress they are far below that attained by Russia twenty years ago, and the Russian people have found that, even with a great deal of outside help in the way of completed equipment and tools, a period of twenty years is insufficient to build up to the desired level. Such reflections will be induced in any one who goes through a modern steel mill, and observes the enormous equipment required to produce steel at a cost which permits of its widespread use. The evolution of this equipment has been possible only through developments ranging over the whole field of engineering in the broadest sense of the word. Accordingly, the applications of science to the metallurgical industry cover an extraordinarily wide range, from the principles of physical science on the one hand, to their application to the operation and control of mechanical, electrical, chemical, ceramic and metallurgical processes on the other.

In what follows I shall refer mainly

to steel, and take its development as typical of the metallurgical industry. For this my apology is that steel is the most widely used of all the metals and alloys and that I am somewhat more familiar with it than with the other metals commonly used on a large scale—copper, zinc, aluminum, nickel, lead, tin and their alloys—except perhaps in so far as they are used in conjunction with steel. Moreover, what is said about one metal applies more or less to another, for all are similar in many respects and differ only in detail, these differences being largely what one would expect from the position of each in the periodic classification of the elements, particularly as reflected in melting point and general chemical properties. For instance, lead oxide is easily reduced to metallic lead, iron oxide is considerably harder to reduce, and aluminum oxide is so stable that a somewhat roundabout method is used to make aluminum; yet the principles involved are identical, although the actual methods appear to differ markedly. Further, a given change in the type of crystalline structure of a metal, whether brought about by addition of another element or by mechanical or thermal treatment, will produce the same kind of change in its properties, though with differences in degree depending upon the metal.

Let us return now to the quantitative development of the industry, using iron and steel as typical. A century ago the total yearly production of pig-iron in the United States was only about 25,000 tons, the world production being about two million tons; of this very little was made into, and used as, steel which is an iron-carbon alloy capable of being hardened by heat treatment. Production increased gradually until about 1870, when the utilization of the Bessemer converter and of the open hearth furnace, both newly invented methods of turning iron into steel, brought about a greatly accelerated rate of production of steel. The outcome is that an annual production in the United States of decidedly less than one million tons 60 years ago increased to some 20 million tons 30 years ago and is now potentially nearly 50 million tons. At the same time the price of a ton of steel has dropped from about \$160 to \$60; that is, in 60 years it has come down to 40 per cent. of what it was, in terms of dollars, and to less than 20 per cent. on the basis of the buying power of the average citizen. The amount of steel now in use in the United States is estimated as being in excess of 1,000 million tons, or on the average, about 18,000 pounds for each person.

I mention these figures to show you that, until recent years, the main effort of the steel industry was centered on satisfying the rapidly increasing demand for mere quantity of more or less standard products. The greatly increased rate of production and the cheapening of the product which enabled consumption of steel to expand so greatly, was made possible by the use of larger and better integrated units, and this in turn by the use of machines to cut down the amount of strenuous labor previously required. These cumulative improvements are due to the efforts of a whole host of men, some of whom made their contribution in totally different fields—as, for instance, in electrical engineering—and with no thought of its application to the production of metals. This labor-sparing machinery has brought about, not a decrease, but an increase in the number of men employed directly in the steel industry; and this has of course been accompanied by a very great increase in employment in those industries using steel in the large quantities made commercially possible by its quality at a low cost. It now looks as if no further *appreciable* lessening of the dollar cost of steel per unit of weight is possible through the use of still larger units or of further labor-sparing machines. On the other hand, the gradual exhaustion of the visible supplies of high-

grade ore will force the use of lower-grade ore, and this will undoubtedly cause some increase in labor cost per unit of weight of metal produced.

It is possible, however, to lower the cost per unit of service by improving the quality of the product, that is, by ascertaining how to make a metal precisely suited to each of the manifold uses to which it is now put. For the city-dweller is literally surrounded by steel in one form or another, yet to him it is just steel. He rarely realizes the fact that the steel in the body of a modern automobile differs in many ways from the steel in railroad rails and in freight cars; in other ways from that in the structural members of great bridges, skyscrapers and ships; and that many special steels are used in machines of all kinds, from agricultural implements through machine tools to high-speed engines. The consequence of this is that steel is made to some thousands of different specifications, each supposed to describe the best steel for the particular purpose. This demand, which in recent years has become much more insistent, for steels of higher quality yet at no higher cost, raises many new problems which have necessitated a fundamental examination to discover what actually happens in each of the long sequence of processes from ore to finished product.

In examining and endeavoring to analyze the processes employed in an ancient art which has already reached a high stage of development, one is likely to meet not only scientific difficulties because the art has far outrun the science basic to it, but also some more or less passive resistance on the part of those who practise the art. The scientific difficulty is to find a sure foundation of fact on which to build; the psychologic difficulty is to get on close enough terms with the practical man to be in position to distinguish between his observations and his inferences. The former are usually right; the latter may or may not be right, largely because there is a nearly universal tendency to simplify unduly by trying to ascribe difficulties in operation to the variation of a single dominant factor, yet with different men upholding different views as to just what that factor is. As a matter of fact, all of them are usually right to the extent that each of these several factors plays some rôle; consequently, in a proper analysis all the factors have to be taken into account and their relative significance to the result assessed with all the means available, whether by statistical analysis or by direct experiment in which one controls as many of the significant factors as possible.

The lag in scientific understanding of metallurgical phenomena was due to the complexity of the phenomena; to the slow development of the requisite experimental technique (a large part of which was initially evolved with quite other ends in view); above all, to the lack of the theoretical principles requisite to a proper interpretation of what is going on, not only in the extraction of a metal from its ore but also in the crystallization of a molten metal or alloy (and metals are used predominantly as alloys) and in the subsequent manufacturing operations. These points we shall now consider more fully.

Half a century ago there had been a great deal of rather scattered investigation of the extraction of metals from their ores, which had led to results in some cases unsurpassed until recently; but there had been little systematic study of the many problems met by any one who tries to correlate and comprehend the behavior of metals and alloys and how this behavior is associated with the previous history of the specimen examined. There had been chemical analysis, often incomplete from the standpoint of present knowledge, which told the relative amounts of the several constituents analyzed for; but these analyses, even though complete, give no information as to how these constituents

are combined with one another, as to what may be termed the molecular architecture of the metal structure. This is, as is now realized, much more significant than the mere gross composition as revealed by analysis; for it fixes the real crystalline structure which in turn determines the useful properties of the metal. This leads me to emphasize that in discussing metal properties, we should aim to relate them primarily to the real structure of the metal and not merely to its chemical composition, this being only one of the factors determining the intimate structure. The consequence is that the validity of many data on metals to be found in engineering and physical tables is open to serious question, not because the measurements as such are unreliable, but because they refer to a particular specimen of a given composition but of unrecorded structure.

Three simple illustrations from other fields will serve to emphasize the point. In the chemistry of compounds of carbon, hundreds of cases are known in which compounds, of identical gross composition, differ widely in properties by reason of differences in the grouping of the atoms, hence in the molecular structure of the compound. Again, diamond and graphite are both composed of carbon atoms, but differently arranged, as has been definitely proved by application of x-ray analysis. The third instance is that a proper mixture of the three oxides, lime, alumina and silica, is of little use as a cement; yet if the mixture is heated to the appropriate high temperature, we get portland cement. The gross composition as determined by analysis has remained unchanged, but at the high temperature, the simple oxides have united to form compounds, dominantly tri-calcic silicate, which is the essential constituent in portland cement. Thus the valuable properties are due to the way in which the several oxides have combined, and this can be told only by the use of methods beyond ordinary chemical analysis.

The key which opened up the whole question of metal structure had been furnished, sixty years ago, by Willard Gibbs, who in 1876 and 1878 presented to the Connecticut Academy the two parts of his memoir entitled "The Equilibrium of Heterogeneous Substances." This great paper is by competent opinion generally considered "among the greatest and most enduring monuments of the wonderful scientific activity of the nineteenth century," and puts its author in the class of the outstanding men, such as Newton or Faraday or Maxwell or Einstein, who have given a new direction to scientific thought. The significance of this paper was immediately noted by Maxwell, who in 1876 wrote that the methods introduced by Gibbs are "likely to become very important in the theory of chemistry" and "more likely than any others to enable us, without any lengthy calculations, to comprehend the relations between the different physical and chemical states of bodies." Apart from this, little attention was paid to this paper until after 1892, in which year a German translation by Ostwald was published. In this way it came to Roozeboom's attention, and thus to general notice, and Gibbs's methods gradually became known to chemists and metallurgists as an indispensable tool in solving the many problems confronting them.

I have recounted this matter, not only to emphasize the great debt which we all owe to Gibbs, but also as a means of bringing out two points. First, that the phase rule—which is the part of Gibbs's work most generally known and most widely applied hitherto—is merely a qualitative statement of the relation between the number of unknowns and the number of quantitative equations which express the conditions of equilibrium; it is properly applied only when we are dealing with equilibrium, and is not needed when all the necessary quantitative data are available. The phase rule is but a part of Gibbs's work, whose quantitative expressions are only now beginning to be ap-

plied to the successful analysis of metallurgical problems. The second point is the long time, fully a quarter of a century, which elapsed between the birth of this idea and its extensive use as a tool in the interpretation and simplification of data which otherwise appeared so complex as to defy a useful or consistent interpretation. Let us therefore see to it that we keep our eyes and minds open for ideas which may assist us in solving our manifold technical problems, even though these ideas may seem to be somewhat highbrow and to have no immediate application to the improvement of our processes and metals. For there can be no doubt that the methods of thought originated by Gibbs have increased enormously our command over processes, enabling us to calculate their efficiency and thereby to get a much better yield of the thing we want; they have entered, directly or indirectly, into almost all lines of manufacture and have thus enriched the world immeasurably.

As these methods became more widely understood, in the early years of the present century, they brought about great activity in the investigation of systems of all kinds, of alloy systems amongst them. The field of investigation was so large and promising, and the number of competent investigators was so small, that most of these studies were, from our present point of view, rather superficial. But for this they are not to be blamed, because their results found immediate practical application and began to clear up many questions which until then had been far from clear. Moreover, they could use only such experimental technique as was then available to them; this, by present standards, was rather crude and was brought up to its present level only by the work of many men working along many different lines, largely without any thought of possible application towards the solution of metallurgical problems.

The development of this technique is worth dwelling on for a moment, as many of you may not realize how recently some of the tools now used every day have been brought to the stage that they are completely reliable if properly used. In the first place, the temperature scale was not definitely established for temperatures above a red heat until about 1910 with the publication of comparisons of gas thermometer readings with the indications of platinum-platinum rhodium thermocouples.[1] At that time it was difficult to get wire for thermocouples which would give reproducible results, and an enormous amount of work went into this general question before it became possible to secure wire for thermocouples of the high quality and uniformity now commercially available; and it was only as this work progressed that men gained confidence in the reliability of the indications of thermocouples properly used. At that time, moreover, it was difficult to obtain satisfactory potentiometers, galvanometers or other accessory measuring instruments; and those which could be bought had to be handled very carefully and were subject to minor troubles of one kind and another to such an extent that it was seldom possible to use them satisfactorily more than two days out of three. Thus it is only within about 30 years that even the best data on high temperatures have been precise enough to have much significance, and still more recently that one could readily obtain instruments which are easy to operate and are reliable day after day.

So much for the measurement of temperature which, as I need hardly remind you, is one of the most significant factors in metallurgical processes, and must therefore be controlled as closely as is feasible. There has also been a great development in apparatus and equipment which enable an object to be heated and maintained at constant temperature for any length of time desired. The point

[1] Indeed the accepted melting temperature of platinum was changed from 1755° to 1773° C. as late as 1931.

is that many operations, involving uniform constant temperature, now readily done have become feasible only recently. To hold a high temperature constant within 1° for any length of time was a feat twenty years ago, but is now commonplace, even if such precision is not always attained when it is supposed to be.

Concurrently there have been improvements in the metallurgical microscope and in the technique of the preparation and microscopic examination of metal specimens, improvements which have enhanced the certainty of interpretation of the observations. This interpretation of structure has been greatly aided by the introduction and development of x-ray analysis which has brought essential certainty in many places where otherwise we would have had to rely on inference. Other refined physical methods which have been applied, or will be made use of, might also be mentioned, but further illustrations are not needed to show how recent is the application of most of the indispensable physical tools in use every day. Moreover, other physical tools are now doubtless in course of being forged, for future use. There has not been a corresponding development of the mechanical methods of test, or in the interpretation of the results of mechanical tests in terms of definite properties of the metal; this seems to be a more difficult matter, but it appears not to have attracted competent fundamental thinking at all comparable to that which has been devoted to physical and physico-chemical methods. There are indications, however, that this situation is becoming more generally recognized, and that these methods of test are going to be scrutinized and studied intensively. At present they can be regarded as little more than conventional tests suitable for ordinary engineering purposes, but measuring an indefinite grouping of properties which can not be definitely resolved into the several components. This was of little consequence when the unit stress in service was low and the factor of safety was high; but it is becoming of significance now when metal is used at high temperatures and pressures, as in high-pressure steam plants or in oil-refining equipment, with a factor of safety coming down towards unity.

Such considerations lead one to the view that many of the experimental data which we are accustomed to regard as reliable may, on critical examination, prove to be less reliable than is supposed; consequently that many of them will have to be redetermined, by modern methods and equipment, with a better real accuracy than has been practicable until recently. To do this involves a great deal of work, attention to many fine points, and in each case the use of all the diverse methods which can be brought to bear upon the problem. A few examples will illustrate the point.

Most metals are used not in the pure state (in which their usefulness would be decidedly limited) but admixed with one or more other elements, which may be metals or non-metals. Since the properties of the resultant alloy depend upon its intimate structure, we must, by appropriate experimental technique, seek information on just what happens when an element is added to a molten metal, which is then allowed to freeze and to continue to cool at an appropriate rate. The results are gathered together in a so-called equilibrium diagram, of the type first proposed by Gibbs. This is in effect a map of the behavior of the system in question throughout the temperature range, on the specific basis that the temperature changes slowly enough to insure that there is always equilibrium between the several phases present; and such a diagram is absolutely fundamental to a proper understanding of how to handle the particular alloy system so as to secure the best results. Now despite all the work which has been put on it, there are still minor uncertainties

in the equilibrium diagram of the iron-carbon system, which is basic for ordinary steels; and there are considerable uncertainties in the diagrams when a third component is present—for instance, manganese or silicon, which are present in all ordinary commercial steels. Indeed, I know of no diagram for a metal system which can be regarded as completely established, and am sure that, when some of the points now in question are fixed, this knowledge will, in some cases at least, prove to be of practical significance.

The defects of the available equilibrium diagrams for metal systems are due largely to the fact that some of the reactions go only slowly, or even very slowly—a fact which has been adequately grasped only within a few years—and consequently, in the experimental work, insufficient time was allowed for the continuous establishment of equilibrium. As an instance, the diagram for the iron-carbon-manganese system was, in part, in error by some hundreds of degrees, because the reaction actually takes weeks to attain equilibrium instead of minutes, as had been presumed. Indeed the significance of time—that is, of the relative slowness of some metallurgical processes and reactions—can hardly be overemphasized; and there is as yet no way of foretelling just how fast any particular reaction will proceed, apart from the general statement that the rate will be greater the higher the temperature, other things remaining equal. The influence of time, or rather of time and temperature jointly, can not safely be neglected in any one of the long sequence of operations between the ore and the finished product; it is particularly marked in the process of heat treatment, the purpose of which is to develop the structure best for the particular use. The rate of response of the metal to certain heat treatments is associated somehow with the size of the crystal grains of which it is made up, or with the temperature range within which the grains begin rapidly to coarsen. In the case of steel the transformation of the structure appears to start at the grain boundaries, hence to go faster to completion when the grains are smaller; whether this is due to material which was thrown out of solution as the grains crystallized from the molten metal and was thus segregated at the boundaries, or to what may be called unorganized atoms at the boundary which belong to neither adjacent crystal array, or to something else, is a question awaiting further investigation which, to be successful, may require more powerful tools than are now available. Whatever be the mechanism in this particular case, one factor in it in the case of steels seems to be a very small proportion (0.02 per cent. or less by weight) of oxygen dissolved in the metal matrix; this may serve to illustrate the precision with which steel must now be made when it has to meet the rigid requirements now more and more often imposed upon it.

A very important phenomenon in which time and temperature enter is that known as aging, which refers to a change in the metal in some cases desirable, in others, undesirable and to be avoided, if possible. This change, in a typical instance, is a strengthening and stiffening of the metal which may proceed over a period of weeks at ordinary temperature, over a period of hours at the temperature of boiling water, and of seconds at some higher temperature beyond which the metal begins to soften. The phenomenon is associated with a precipitation throughout the metal of a very small proportion by weight of finely dispersed, initially invisible, particles of some compound which was soluble in the metal at high temperature but whose true solubility limit has been exceeded at the low temperature. The major part of the effect occurs before the particles are visible under the highest power now available of the microscope; and the effect disappears and reverses

as the tiny particles coagulate to larger particles or are redissolved. The compound precipitated may be an intermetallic compound, as in the case of the high strength aluminum alloys in which the strength is developed by regulating this precipitation hardening; or it may be an oxide or nitride or carbide, as in the case of steel, where the phenomenon is avoided in so far as possible, as it is not unlikely to cause trouble. There is no doubt of the fact that incipient precipitation of a disperse phase in a metal stiffens it; there is no very satisfactory explanation of how this is—but neither is there of any of the mechanical properties of a metal.

As an instance of this, many steels rapidly lose ductility as measured by an impact test—that is, become rather brittle—as the temperature of the steel is lowered towards 0° F. This is of considerable practical importance wherever steels are exposed to impact at low temperature, as in railroad rails in the Northwest in winter and in equipment for the production of low temperature; and care must be exercised in the choice and treatment of steels which will be exposed to such conditions. The temperature range within which this rapid loss of impact-ductility occurs depends markedly upon how well the steel was deoxidized, and to a lesser extent upon the prior heat treatment of the piece. As the temperature is again raised, the steel immediately regains its ductility; this is fairly positive evidence that this brittleness is not associated with a precipitation, but is to be ascribed to the different influence of temperature upon the several properties—cohesive strength, shear strength or whatever they may be—which in combination determine brittleness or ductility. Moreover, whereas the ductility of a certain grade of steel, as measured by impact strength, may be quite low at about 0° F., the ductility of the same piece as measured by elongation under tensile stress diminishes to the same relative extent only at a far lower temperature, and the ductility in torsion remains unchanged even at the temperature of liquid air. Thus there are at least three types of ductility, according as one judges from impact, stretching or twisting, which implies that these correspond to different combinations of the fundamental properties of the crystal aggregate.

What I have said will, I hope, convey to you the idea that some of the useful properties of a metal are influenced by factors which are very elusive and hard to disentangle, even though other useful properties are largely or wholly unaffected. Present research is largely directed towards a better understanding of just what these apparently tiny factors are, and how to control them to the end that the metal will satisfy the multifarious demands of the user. For instance, some properties appear to be influenced by the presence of as little as 0.001 per cent. by weight of some element; and this raises problems of proper analysis, particularly perhaps when the element is oxygen or nitrogen or hydrogen and may occur in more than one form in the solid metal. Moreover, in some cases these tiny constituents are harmful, in others they are needed in the right proportion for best results. That is, for some purposes we require metal as pure as it can be made; more often we seek to get into it—apart from recognized alloying elements—the right small amount of an "impurity" properly distributed through the metal.

This leads to a few words about alloys, in particular about alloy steels. Steel itself is an alloy of the elements iron and carbon; it usually contains small proportions of manganese and silicon and very small proportions of some of the nonmetallic elements, but none of these need concern us at the moment. When certain elements, such as chromium, nickel, molybdenum or vanadium, are added intentionally, the resultant metal is commonly called an alloy steel; but there is no sharp line of demarcation, and usage

is not always consistent. In any case the significant point is that all steels are primarily alloys of the chemical element iron, of which few contain less than 95 per cent., and most contain 98 per cent. or even more; and they owe their range of properties to the peculiarities of the element iron and of the iron-carbon system, peculiarities which are merely modified by the presence of other alloying elements. To discuss this matter would lead too far; it must suffice to say that we now have a fairly consistent general picture of the family of steels, though much remains to be learned about many features in detail.

The properties of any alloy steel—indeed of any alloy—are not a mere matter of its chemical composition; but one has, in each case, to find out just how to treat it to develop its good properties to the fullest extent. Moreover, the treatment best for one property (for instance, toughness) need not be the best for another (for instance, resistance to wear); so that the best securable combination of desirable properties for any particular purpose is usually a compromise. To find a new alloy of superior properties—or even with a single superior property—is far more of an undertaking than is commonly understood. To prepare alloys of a series of compositions is only a starting point for a wide program of investigation to discover the best conditions under which to carry out every one of the many steps between the molten metal and the finished product. Moreover, a new alloy must in general satisfy a wider range of requirements—for instance, it must be weldable and workable, it should have an enhanced resistance to corrosion, it should have favorable properties at high temperature or at sub-zero temperatures—as it is likely to be tried for a wide variety of uses. This means a long period, usually some years, of intensive investigation before it can safely be put on the market, and a much longer period before all its ills have been diagnosed and corrected. One may almost say that there is better information about a new alloy than about the old metal which it displaces, just as there is more definite detailed information about welded joints than about riveted joints; for we must have measurements, and many of them, on the new thing to offset the general experience with the old.

The difficulty of assessing a new metal seems to be quite inadequately appreciated by the many inventors and promoters with patented or secret methods of improving metals, to judge from the arguments they adduce. Some persons go on the principle that a metal will necessarily be improved by additions of some rare chemical element, and the rarer the element the more wonderful is its effect likely to be; or by the use of some "catalyst" discovered by the promoter or his foreign friend—for distance, which is said to make the heart grow fonder, apparently makes the promoter's heart grow fonder of the merits of the project. Others have an almost fanatical conviction that to do something very difficult and costly—such as holding tons of molten steel in a high vacuum—would yield a truly grand product. Those who make such claims are wont to present them without any qualification whatever, and by so doing are likely to impress the man with little or no scientific or technical background, so that they may be believed by him as against the scientist who is unwilling to make unqualified statements until he is sure of his facts—and this, as I have outlined above, may require a great deal of time and effort.

For many years there has been a continuous trend towards a more extended use of lighter products and a more limited use of the heavier products of the metal industry. This is in part merely what one would expect in the present state of evolution of the country as a whole; but in part it is due to the substitution of thinner for thicker material, a substitution which during the last few

years has been going on at a rapidly accelerating rate. For instance, the steel used for automobile fenders is now only half as thick as it was a decade ago, the thinnest part of the finished fender being little more than 0.02″ thick. Substitution of thinner for thicker material means that in service the metal is subject to a higher unit stress; and in general it is not safe unless the metal has an appreciably higher resistance to atmospheric corrosion than was required before, for it is obvious that the thinner the metal the greater is the relative weakening of the structure caused by a given depth of corrosion. It is clear, therefore, that a steel to be substituted in order to save weight must—since there can be no appreciable reduction in the weight per unit volume of the metal itself—be both stronger and more resistant to corrosion. The former requirement is not hard to meet at a reasonable cost, the latter is more difficult; it is now receiving a great deal of intelligent attention, and decided advances are being made in the production and application of metals for lighter moving structures.

The essential difficulty is that all ordinary metals (except the so-called noble metals) are essentially unstable in contact with the atmosphere, and tend to revert spontaneously to oxide. This tendency can be hindered only by interposing some sort of barrier between the metal and its environment. This barrier may be an applied electroplate or a coating of paint or other protective material; but it is preferably an oxide film, developed naturally by the metal, as in the case of aluminum, chromium and the chromium stainless steels, which is adherent and impervious, and so prevents further attack. The best way to lessen corrosion in a given type of environment is thus to discover the metal composition which in that environment will develop a film resistant to the progress of the reaction. In this search there is at the moment little to guide us, and we can proceed only by long-time tests on long series of compositions and treatments, carried out under different types of atmospheric conditions. For corrosion, depending as it does upon the environment as well as the composition and homogeneity of the metal surface, is not one problem but a multitude of problems; and so a test made under one set of conditions, as in an accelerated laboratory test, is not a trustworthy guide in predicting the rate of attack under another set of conditions even when the differences might seem to be slight. There is therefore a large problem, the proper solution of which awaits further knowledge of precisely what happens in the atomic layers at the surface of a metal in contact with any environment. With such knowledge it should be possible to find a means of developing on the metal the right kind of protective film.

Perhaps I should point out that metallurgical advances in the direction of making available stronger metals with better resistance to corrosion are, while a direct benefit to the public, in a sense against the interest of the industry in that ultimately they will lessen the amount of metal needed for replacement. For instance, the useful life of a freight car made of some of the newer steels promises to be about twice what it has been; beyond which these cars, being lighter, carry a heavier pay load and are cheaper to operate. Again recent improvements in railroad rails, together with the fact that the railroads are using heavier rails in their main tracks, have enhanced safety, and at the same time the useful life of an average rail has risen from about 10 to perhaps 15 years, according to recent estimates. If this estimate is correct, it means that the rails needed for replacement will be not more than 1¾ million tons annually, whereas the eight rail mills in the United States can produce about 4 million tons.

In many applications of metal there is, of course, severe competition between the

several metals—for instance, between steel and brass or copper pipe, or between aluminum alloys and stainless steel for light-weight moving structures; and in others, there is increasing competition between the metals and non-metallic materials such as artificial plastics and composite sheets and boards. Each industry is trying to enhance the merits, and lessen the defects, of its entry in this competition; and the public is the chief gainer. All this means that the metal industry is in effect forced to improve the serviceability of its product, even though the outcome of this improvement is the obsolescence of its mills and a lessening of the amount which it is called upon to supply, at a profit margin almost certainly smaller than it was before.

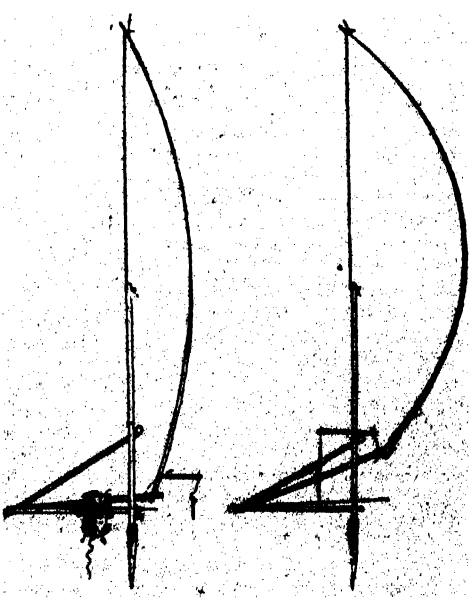
In conclusion, the general situation, as I see it, is that applications of scientific method have brought, and are bringing, marked progress in the winning of metals and in the treatment of metals, the latter particularly in the sense of developing the best composition and the best treatment to fit a given type of alloy to a specific set of requirements. In the eyes of the general public the changes may not have been very spectacular; yet many metal products, though still called by the same name, have been so much improved in serviceability that they are in effect new products for which new names would not be out of place. These improvements come before the public not as such, but as largely unrecognized contributions to striking developments in the transportation industry, or the chemical industry, or the oil industry—indeed, in all industries, for there are few, if any, which remain untouched by metallurgical progress. Such improvement will continue, quite possibly at an accelerating rate; for there is an enormous field much of which has been little more than scratched. Present indications are that the next decade or two will see progressive improvement in the smelting and handling of metals, and gradual changes in the alloys used for the severest service; but that no *radical* change in the industry is in sight. A radical change seems unlikely except as a consequence of the development of some new idea in pure science; and the development of a novel idea into commercial practicability and use on a large scale will require at least a couple of decades, to judge from past experience. Where this idea may arise, what it may be and whither it will lead can not be foretold; it may well appear in a field entirely different from any now being studied by men concerned with the progress of metallurgy. A telling illustration of this is that if a commission of the most forward-looking scientists then living had been appointed a century ago to study methods of improving artificial lighting, it is highly unlikely that even the most visionary member of the group would have suggested a study of the electric current. I would hesitate to make any prediction, beyond this, that in the immediate future, progress in metallurgy will continue, probably at an accelerated rate, in the directions which I have endeavored to outline to you. That there will be changes is certain; what any of these changes will be is unknown, even to those most interested in planning for the future, and if we knew, we would be preparing to put those particular new ideas into practice as soon as possible.

UP MOUNT KINABALU

II. Camping and Collecting in Lumu Lumu and Beyond

By JOHN A. GRISWOLD, JR.
RESEARCH ASSISTANT, MUSEUM OF COMPARATIVE ZOOLOGY, HARVARD UNIVERSITY

After what seemed like a short climb compared with previous days, I came face to face with my new camp at Lumu Lumu. A small clearing had been made in the thick jungle where a hut stood. It was some thirty feet long by fifteen wide. Its walls were covered with bark and rattan leaves, while the roof was of the Kabu leaves. At one corner and adjoining the hut my little wall tent was pitched on a platform of rough-hewn logs. To the right of the clearing a small icy-cold brook appeared for a few feet and then was swallowed up by the jungle. The whole open area was not more than thirty feet wide and a hundred feet long, with stumps everywhere and felled trees piled on one another. This open space was to afford us a little sunshine on those so few days that we were blessed with it.



DUSUN RAT TRAP, SPRUNG AND SET

Labuan and his fellow villagers had certainly done a grand job. With parangs, a little larger and heavier than butcher's knives, they had felled trees two feet in diameter, made a house, floored it with logs and built a waterproof roof—all in two days.

After a few days I saw why previous scientists had never spent more than ten nights here, because day after day it rained, the mist came down, and it grew bitterly cold. My men were sleeping under six blankets, the fire was kept going continually, and I wore woolen stockings and a thick woolen sweater, while my skinner almost sat on the fire in his efforts to do his work. Undoubtedly the first Dusun word I learned was "Sejouk," which was repeated a hundred times a day and means "darn cold."

At this time I well remembered what Mr. F. M. Chasen, of the Raffles Museum in Singapore, had said about Lumu Lumu. "A colder and damper and a more miserable place I have never been in. I really feel that it was after that trip that I lost my real love for camping." He was there for about ten days. Mr. Evans was of the same opinion, as he said to me when I left Jesselton, "I hope you block up your trail well before you leave as I don't want to see Lumu Lumu ever again." At first I shared their opinion, but I grew to like it as time went on and the weather improved.

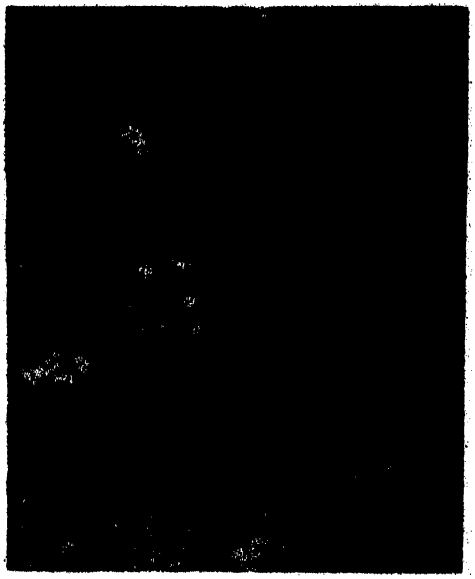
Trapping here was very poor, but since I knew that every rat and squirrel that

I caught could be found nowhere except on this famous mountain, before I left I had over one thousand traps set, stretching in all directions. It took three men a half a day to visit all the traps, for some of them were over two hours away. Since a set of traps was only good for two weeks at the outside, they had to be frequently moved to an untouched district, for on some days all the traps were empty.

Realizing within three days that my factory-made traps were absolutely useless, I went native and used nothing but the Dusun bamboo contraptions that caught anything from a frog to an animal weighing two pounds. It would be a difficult matter to give an intelligible description of how one of these traps works, but they vaguely resemble a guillotine wherein a piece of bamboo, descending from above, pins the rat by the neck to a lower horizontal piece. The motive power is supplied by a bow-shaped piece of bamboo that acts like a spring. These traps are easy to make, light, efficient and easy to set.

The native method of placing these snares is very interesting and can clear out a district in short order of anything that walks or crawls on the ground. They are set in long lines some ten or twenty feet apart. The intervening spaces are blocked up with brush, logs or anything that is handy, to a height of from six to eighteen inches, to form a continuous wall sometimes a mile in length. Thus, any animal wishing to cross over must pass through one of the openings where a trap is ready to catch it. This sounds easy, but it takes a lot of experience to know where to set a trap in order to get the best results and cover the trails of a creature as small as a rat.

The Dusuns being very fond of rat pie and being excellent and persistent trappers, it is of little wonder that certain ground-loving birds, like the red-headed



PACKING UP TO GO HOME

partridge, are almost extinct and are now only to be found in the remotest districts.

The excessive dampness of Lumu Lumu was something we had to contend with day in and day out. It was impossible to start a fire without first drying the wood in the sun or on a rack over

DUSUN WOMEN IN GALA REGALIA AT THE TENOMPOK MARKET. DAUGHTER ON THE LEFT, MOTHER ON THE RIGHT.

the fire and, even so, the fire had to be kept going by constant blowing through bamboo tubes. Likewise all skins had to be kept in a sort of tent cupboard with a fire in it, or a lantern burning to take some of the humidity out of the air. Whenever the sun shone, everything was put outside to dry. Sometimes they were taken back and forth four or five times a day when rain threatened.

Practically every day we had visitors from Bundutuan village. Men and children brought vegetables, snakes, bats, birds, animals, shells and fish for sale, though soon they came less and less frequently, as they told me it was too far to bring a few frogs. I soon solved this new problem by giving them large bamboo containers with the proper solution of formaldehyde which enabled them to collect a large number of specimens before making the three-hour journey to my camp. This idea at once met with their approval and was most profitable to both them and me. Soon fish, shrimp and shells came in by the hundreds, and frogs, snakes and lizards by the tens. As I paid a much higher price for mammals, it was to their advantage to come with only one or two. An animal the size of a badger, civet cat or monkey commanded the highest price.

At least one or two men of a group of visitors would have their blowpipes with which they would "pepper" any little bird they saw. Blowpipes are made from some very hard wood and were formerly drilled out by water power from a large log and then whittled down to the right dimensions. The art of making blowpipes is very specialized, so that only a man having two is willing to sell one. Either darts or clay pellets are used, and in the hands of a good hunter their accuracy is astounding. A match box stuck on a stick at fifteen paces was hit once in every three tries and a chicken at seventy feet was a "walkover."

Monkeys at Lumu Lumu and lower down were scarce, the crab-eating monkey (*Macaca irus*) being the most common. The pig-tailed macaque was also to be found. There were three varieties of langurs, of which the red langur was the most spectacular with his beautiful Irish Setter pelage. Gibbons were heard on several occasions, and one was collected. One day, very close to camp, Labuan saw a large orang-utan.

I had several Italian bird-net sets, but they took a great deal of time to keep in running condition. They did, however, catch several bats that I was unable to procure in any other way. On one occasion "Minnie," my pet monkey, got loose and became terribly tangled up in the meshes of one of the nets set near the camp.

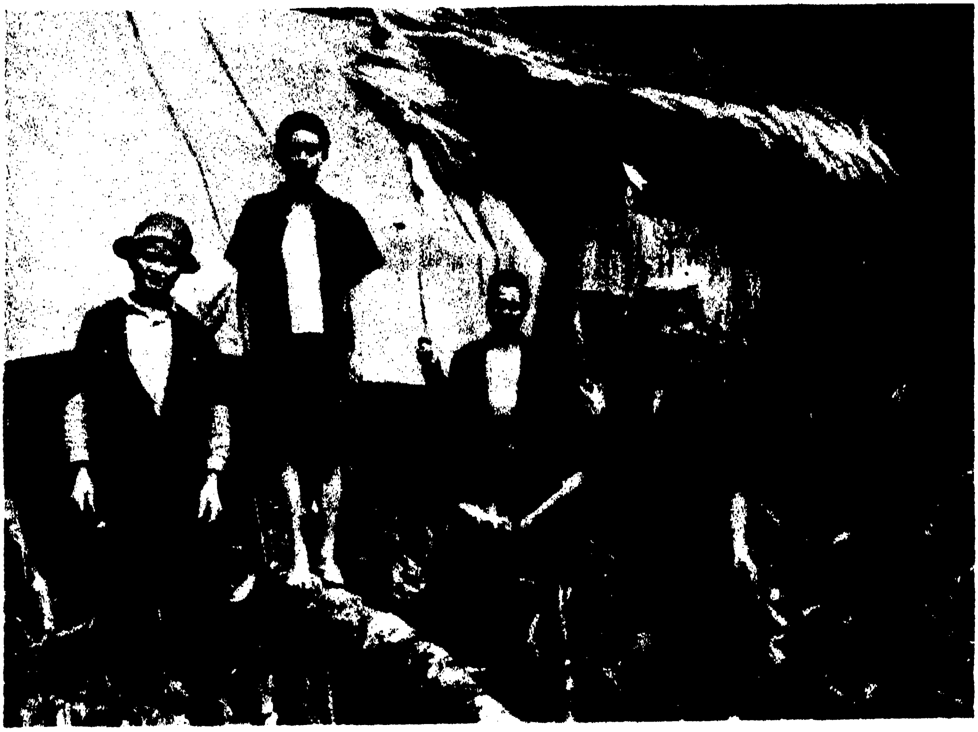
"Minnie" was seldom without company, because I bought several pet macaques from the natives. A little four-months old baby named "Pesang," which is the Malay for banana, was most amusing. Never being tied up, he would make sallies on the kitchen to the depletion of our banana supply. Minnie's failing was Lifebuoy soap, when occasion afforded a chance for her to reach my washstand. Minnie and Pesang were inseparable companions, the former taking a motherly care of the latter, carrying little Pesang around and spending hours in vain search for fleas.

Evenings in camp were never monotonous. While I sat and wrote up my catalogues or skinned, one of the natives would play the "Sumpotan," a musical wind instrument made from a gourd with bamboo pipes set into it. The pleasing sound it produced was like a small organ, far preferable to most native contraptions that pass as musical instruments.

On frequent occasions these peaceful hours before retiring were rudely disturbed by a yell from one of the men as he jumped up and scratched himself, and

PAKA CAVE IN THE FOREGROUND
WITH THE AUTHOR'S SHELTER IN THE BACKGROUND, 9,700 FEET.

CLOSE-UP OF PAKA CAVE
GINDA SATU IN DOORWAY.



CAMP AT PAKA CAVE, WITH DUSUN HELPERS
LEFT TO RIGHT: TONGAL, LABUAN (HEAD BOY AND NATIVE GUIDE), GINDA SATU, AND GINDA DUA.

then would ensue a frantic search with a long pair of forceps for the offender, which was usually a centipede of astounding dimensions that had been so bold as to take a nip at somebody's bare leg. Its final destiny was the collecting bottle of alcohol kept handy for just such occasions.

Almost every night a weird cry was heard near camp and, as the days rolled by without being able to discover its identity, many theories were advanced as to its origin. First it was an owl, then a civet cat, and finally a flying squirrel, which it proved to be when I at last shot one.

The next to last night that I spent at Lumu Lumu, while I was working, I heard what sounded like a gentle rain close to camp, but knowing that the sky was clear I arose, picked up my gun and headlight, and crept out into the starlit night. Then I discovered it was a shower of small twigs falling from a nearby tree. I switched on my light but failed to see either bird or animal. I was slowly circling the locality, when I suddenly picked up the eyes of a giant flying squirrel. So close was it that I could clearly see its black back with its white tickings. The squirrel was hugging the trunk of a small tree some twenty feet above the ground. In spite of my close proximity I realized I would have to take the chance of blowing it to pieces or losing it completely, because at any moment it would climb upwards on the opposite side from me and then would be lost from sight by a long silent glide that would easily carry it a hundred yards. I aimed a little to one side and fired. Luck was with me, and I picked up my second specimen of

this interesting species. The first one I had shot from the door of the camp early one morning a week previously. The only other known specimen of this giant flying squirrel was collected five years previously by a botanist passing through Lumu Lumu, who had killed one with a stone.

When trapping and shooting slacked off considerably, I decided to change camps and send my personnel to Kiau while I made a ten-days' trip to Paka Cave, two and one-half hours below the summit, before rejoining my men.

Fifty porters, the high priest's son and the high priest's helper arrived on the third of August. Of these, eleven were to carry my equipment to Paka, leave me there, and return in ten days to take me to Kiau. That night the cabin was jammed with men and women who, in spite of the cold, were very jovial. The

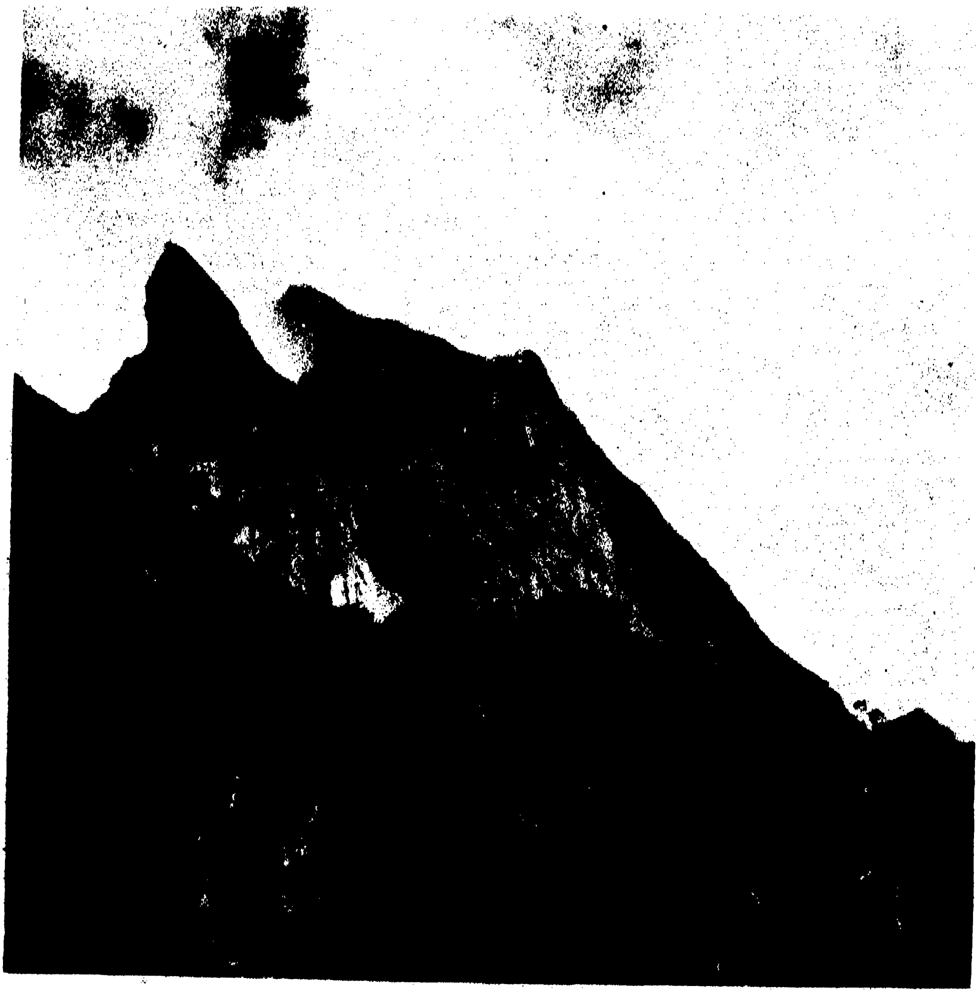
INTERIOR VIEW OF AUTHOR'S CAMP AT PAKA CAVE

NOTICE THE POT BLACKING ON THE FACE OF THE NATIVE WITH THE HAT ON. THE AUTHOR IS IN THE FOREGROUND.

place reeked of tobacco smoke and human bodies, and the fire smoked more than ever. During the lulls in the babble of human voices, we could hear the faint jingle of metal from the belts of Bornean five-cent pieces that encircled the waist of every girl.

The following morning, I proceeded up hill to Kemberanga, a small clearing some two hours above Lumu Lumu. On the way, four men and I gathered up traps that I had previously ordered piled up in preparation for this trip. One is supposed to "lose face" if a Tuan carries anything more than his body, but I carried some traps, for I was very anxious to get as many up to Paka as possible, because nobody had ever done any serious collecting on the higher slopes of the mountain.

Arriving at Kemberanga, I found that the sacrifice was finished. It was here that Whitehead is supposed to have spent six weeks in 1887 making that remarkable collection of birds that established his reputation as an ornithologist.



SAYAT SAYAT, 12,000 FEET

ON THE SOUTHWESTERN SLOPE AT THE TREE LIMIT.

BASE OF LOWE'S PEAK NEAR WHERE THE LAST SACRIFICE TOOK PLACE

THE NATIVE ON THE EXTREME RIGHT IS THE HIGH PRIEST'S SON, AND NEXT TO HIM, LABUAN. THE REST OF THE NATIVES ARE PORTERS, WHO ARE WEARING MY CLOTHES TO KEEP WARM.

The five-hour climb to Paka is the most grueling of all the stages. The ascent is steep, the ground is strewn with rocks, and the rarity of the air makes breathing difficult. The trees become more stunted, and pitcher plants of at least four varieties become abundant. Of these, *Napenthes Raja* is the largest and was named after Raja Brooke of Sarawak. It has an egg-shaped pitcher nineteen inches in circumference.

Everybody was glad when we finally reached Paka Cave at an altitude of 9,790 feet. The so-called cave, which is really nothing but an overhanging rock, is on the edge of a small stream, the source of the Kadamaian River. A shower of rain on the bare mountain top is enough to convert this little stream into a raging torrent which comes down in a roar of ever-increasing intensity, so that you have to shout to be heard. Only a person with the very highest sense of cleanliness would venture to bathe in its icy waters. I had my tent and tent fly rigged up on a small platform we made jutting out from the hillside, well away from the Arctic stream, for the cave was no adequate shelter for a ten-day halt.

To make the camp warmer we covered the whole tent with "Kajangs," or palm leaf thatch, which previous expeditions had brought all the way from the coast. The tent fly we left uncovered except for its sides, which permitted the light to filter through, and was essential. Under the fly we had a fire going continually, which kept us fairly warm and by which we cooked. Labuan and another of my regular men, seeing how much better it was than the cave, slept with me in the tent. A sleeping bag which a friend had given me for Christmas was ideal for the mountain, and particularly appreciated upon it. Only a constant fire and frequent administrations of brandy kept our spirits up for those ten damp, cold, bleak days spent at Paka. It rained every afternoon. To make things worse, on the eighth day my helpers ran out of food

HARVEY'S PEAK, 12,860 FEET, SOUTH OF LOWE'S PEAK

and were for leaving me, but I gave them the rest of my rice and, with the addition of roasted rats, it saw them through until the porters returned from Kiau.

The forest around Paka is very thick, damp and mossy. The trees are low, "Leptospermum," a sort of bushy tree, being the most abundant. When dry it burns well but not without a good deal of smoke. Around the tent we cleared a few trees to permit the early morning sun to strike our camp because by eleven o'clock the sun is obliterated by mist and it starts to rain.

I was up at dawn the following morning to climb to the summit with the high priest, his helper, Labuan, and three other porters who volunteered to go along. I also took along three natives with fifty traps each to set at Sayat Sayat, which is a flat place on the very edge of the tree limit. By doing this I would secure a collection of mammals from the top of the mountain down to Kiau.

Above Paka the thick, damp forest ceases and is replaced by a stunted vegetation area in which the forest is more open, drier and much less mossy. This continues to the tree limit in irregular spurs, one of which is Sayat Sayat, where the trees have really become bushes since they are so stunted, and rhododendrons, sedge and two kinds of conifers are also present. While crossing a small gully, Labuan found the dried bones and some feathers of a very large bird which were undoubtedly those of a fireback pheasant, a lowland bird which occurs ten thousand feet lower down.

When we reached the base of Lowe's Peak, the last sacrifice took place by a

ALEXANDRA PEAK, 13,135 FEET

small pool of water. The ceremony was as follows: First the priest arranged small bundles of flowers he and the men had gathered on the way to form in a small circle. In the middle he put two eggs, some tobacco, a certain amount of rice and betel-nut. He then squatted down in front of this array with an enormous bunch of charms which consisted of pigs' teeth, queer twisted pieces of wood, an iguana skull and many other unidentifiable "dojiggers" strung on a string. Spitting vigorously, he started his chant, calling to the spirits of the mountain. At the crucial moment, when it came time to cut off the heads of the two chickens, the sun went behind a cloud, but he was vain and obliging enough to wait for it to reappear so that I could take a picture of him "doing his stuff," while the other Dusuns paid no attention to him and chattered amongst themselves. I could never make out whether the Dusuns were absolutely sincere in their beliefs or whether they were like the old lady who bowed at the devil's name in church because "It cost nothing to be polite and, besides, you never know."

Since by this time all the men were shivering and rubbing their hands together, I distributed shirts, trousers, towels and even a pair of cotton gloves. Filling the canteen for the last time and leaving the priest and two others at the sacred pool, Labuan and I made the steep ascent to the top of Lowe's Peak and the highest point on the mountain, 13,455 feet above sea level and Jesselton, which we could see in the far distance. Immediately below us Lowe's Abyss dropped off for

hundreds of feet—clouds veiled its true depths and one might have been looking in the crater of a steaming volcano. All around such peaks as Victoria, Alexandra and St. John's rose like so many medieval sentinel towers that had defied all attacks of the elements for hundreds of years.

I followed the usual custom of writing my name and date on a piece of paper which I inserted in one of the bottles left there by previous visitors, and no sooner had I finished taking some photographs than the thick mist came down and it started to rain. We hurried down and took refuge under a rock at the foot of the peak, where thirteen years previously Messrs. R. F. Evans and C. R. Sarel had spent the night. They recorded a temperature of 30° F. at 6 A. M., and the sacred pool was frozen over. Soon the rain ceased and we again started downwards, but now the water was running on the bare slopes and it was very slippery.

The following day collecting started in earnest. The rest of the three hundred traps were set and the rats and birds that were caught in the traps at Sayat Sayat were skinned. With the possible exception of a shrew, the only other mammal that is truly a resident of this high, sheltered forest zone is a medium-sized brown rat (*Rattus baluensis*), which was very common. One or two specimens of the same mammals that we obtained at Lumu Lumu were also collected.

Of the birds collected, only three were real residents. Of these a very tame thrush (*Merula seebohmi*), not unlike our American robin, was the most abundant. This thrush was so tame that one of my men actually killed one with a stone. The other two indigenous birds of this high altitude were a green warbler (*Horornis oreophila*) and a small brown timeliine (*Androphilus accentor*). It is a very interesting fact that certain birds and animals which Mr. Chasen, of Raffles Museum, Singapore, had collected here at Paka and at Lumu Lumu, were either totally absent or very scarce, although I spent more time at these two localities than anybody else. It, therefore, seems impossible to quote definitely an altitudinal range for certain species. Undoubtedly this is affected both by food supply and time of the year.

During the whole trip we were all very lucky in the matter of ill-health. Some of the men had fevers, another a toothache, and still others stiff necks and stomach aches. Careful boiling of water and eating only cooked vegetables minimized the chances of picking up dysentery, which was ravaging the country. In the preceding ten months a fifth of the population of Kiau died from this disease alone. One of my men who broke out with ugly sores insisted on treating them with soot from the bottom of our cooking pots which only made them worse.

My last collecting station was at Kiau. The Kenokok Valley, an hour's walk from camp, was an excellent hunting ground of very high old forest. Over 60 per cent. of the specimens collected here came from this district. Squirrels of many varieties were to be found in the locality, ranging in size from the giant squirrel (*Ratufa ephippium*), which was nearly three feet in length, to Whitehead's pygmy squirrel, which was scarcely six inches long. This peculiar little squirrel is confined to Borneo and presents an extraordinary appearance with its bushy tail and long tufted ears of grayish white hairs over an inch long. Kiau is a peculiar locality because its fauna is in a most interesting transitional stage, lowland forms occurring side by side with submontane animals. Lizards and snakes were also very numerous in this locality, there being some twenty different species of each.

LOWE'S PEAK, THE ACTUAL SUMMIT, 13,455 FEET

THE SMALL GOVERNMENT REST HOUSE AT KIAU, 3,300 FEET
WHERE I SPENT THREE WEEKS COLLECTING.

GATHERING OF THE MISTS

DUSUNS AT KIAU

'A BUFFALO AND NATIVE TODDY WERE BOUGHT AND THE GUESTS ARRIVED 'EN MASSE.' "

The natives dropping in at the Rest House each evening and morning gave one a good chance to observe them. The young women, however, were very shy and if they saw you so much as glance at them they would turn their heads and giggle foolishly or move away. My long matted hair and bushy beard may have accounted for some of their shyness, for undoubtedly the majority had never seen a beard before.

While I was staying in Kiau several people brought me gifts of buffalo meat, chickens, eggs and one native hat. To show my appreciation for their kindnesses and hospitality, I gave a farewell feast to the three hundred residents. I bought a plump water buffalo and gallons of native toddy, which was specially brewed for this happy occasion. At dusk the guests arrived "en masse"—three hundred strong.

I arranged a contest of native dancing with prizes. At first all the girls were shy, but, goaded on by the onlookers and in anticipation of a mirror or a bottle of

MOUNT KINABALU FROM 3,300 FEET

"I WAS GENUINELY SORRY TO LEAVE THE MOUNTAIN AND THESE JOVIAL PEOPLE.'

perfume, first one pair of girls and then another started in. The music was supplied by a "Sumpotan" like the one we had so enjoyed at Lumu Lumu. The dancing took place in a small circle, and the performance was judged on the action of the feet, legs, arms and fingers. Men specialized in a different sort of dance, which was very fast and featured gymnastics and balance rather than grace and form. They also danced with women, but modified their antics to conform more with the girls, who were quieter and more dignified.

On the 28th of August, shortly after dawn, my little caravan headed for the coast. Trudging behind my porters, I glanced back over my shoulder and a lump came to my throat as I took a last look at this friendly village whose inhabitants had turned out to bid me farewell. Majestically towering in the background with a halo of clouds about its summit loomed mysterious Kinabalu.

THE ORIGIN OF LIBERTY

By Dr. WALTER WOODBURN HYDE

PROFESSOR OF GREEK AND ANCIENT HISTORY, UNIVERSITY OF PENNSYLVANIA

THE one thing which we Americans prize above everything else is our liberty. Whether the theme of the political philosopher or the slogan of the politician, the mere mention of liberty strikes a responsive chord in us all. The slightest anxiety lest its expression be curtailed in speech, press or assembly brings immediate protest. It may be only an idea imperfectly worked out in government and society, but we are not here concerned with its philosophical content further than to recommend the famous "Essays on Liberty" written over three fourths of a century ago by the English philosopher and economist John Stuart Mill, whose analysis of the concept is still authoritative. We feel and know it is more than an idea, a reality which we are ever ready to defend with our lives as we did in '76. The fact that we Americans enjoy liberty while we imagine certain other nations do not, and the ever present fear that we may conceivably lose it ourselves, shows that we regard its acquisition as a human achievement somewhere in the past. Few of us, however, realize when the idea first appeared on earth and imagine that in some form or other it has always been here, at least since mankind began to be civilized. But we shall see that this is a fallacy and that long periods of civilized man passed without it, and that liberty was evolved late in historical times by one and only one great people—the ancient Greeks.

Whatever may be our shortcomings in reference to our knowledge of that wonderful race, we all know that the Greeks were the first people of Europe to emerge from the barbarism which surrounded primitive man. But we should also know that the Greeks were by no means the first in the "Western" stream of culture, which has flowed ceaselessly onward from the dawn of history on the Nile and Tigris-Euphrates. For world culture was already old when the Greeks appeared. From Marathon, the first great date in their story, back to Khufu, the Egyptian pharaoh of the fourth dynasty, who soon after 2900 B.C. erected the Great Pyramid of Gizeh, still with its base covering thirteen acres the largest building extant, just as many centuries have elapsed as from Marathon to our time. And Khufu's reign was centuries down the historical current of Egyptian history.

During that long period before the Greeks overcame the menace of Persia at Marathon and Salamis and became the chief actors on the stage of history, great peoples to the south and east of Greece had arisen, developed their types of culture, waned and disappeared—in Egypt, Crete, Sumeria, Babylonia, Assyria, Lydia, and among Hittites, Aramaeans, Phoenicians, Hebrews, Chaldaeans and Medes—collectively with the later Persians known to us as the Ancient Near East. And most of these were the spiritual ancestors of the Greeks, helping to mould the beginnings of Greek civilization, the best of the ancient world.

Only recently have we become really acquainted with this Oriental background of early European history, beyond the fragmentary references to it by the Greek and Hebrew historians; and learned that the Greeks did not spring all at once into the full possession of their genius, but, like every other people in history, reached the heights of their culture by slow degrees, in their upward march receiving all sorts of influences from the peoples of

the Eastern Mediterranean and beyond. While borrowing much from their neighbors their amazing originality soon assimilated the debt and made it their own. As Professor Brunn, of Munich, the great critic of Greek art, once said, they borrowed their alphabet from the Phoenicians, but with it they wrote Greek and not Phoenician.

The decipherment of the Egyptian hieroglyphics, a little over a century ago from 1822 on, chiefly through the labors of the young Frenchman Jean François Champollion, the founder of Egyptology, first opened to scholars the Egyptian records, while the later decipherment of the Mesopotamian cuneiform script completed by Sir Henry Rawlinson in the years 1833 onwards similarly enriched our knowledge of the various peoples of Hither Asia beginning with the Sumerians in the lower Tigris-Euphrates valley who invented it. They passed it on to their successors here and in adjoining areas where it continued to be used for thousands of years, almost down to the Christian era, when it finally completely surrendered to the Phoenician character which with modification we still use.

Only since the turn of the present century, however, and especially in the last dozen years have we really come to know the Oriental peoples intimately through archeological excavations. In 1900 Sir Arthur Evans, the English archeologist, began one of the most remarkable triumphs of archeology—the discovery of a hitherto unknown Bronze Age culture in the Aegean area. For this discovery, extended by the labors of a group of international scholars, literally added an entirely new chapter to history. While we can not yet decipher the Cretan script found on pottery, sealstones and unbaked clay-tablets—at least beyond a few numerals—we know from visible remains that Cnossus on Crete, the great isle midway between Greece and Egypt, was the center of a far-flung sea-power as early at least as the beginning of the third millennium B.C., which lasted on to around 1400 B.C., and still later on the mainland of Greece, its final complete destruction being the work probably of Hellenic invaders. This thalassocracy controlled not only the commerce and politics, but largely the culture of an immense area, extending northward from Crete to sites on the Greek mainland—Mycenae, Tiryns, Amyclae, Corinth, Athens, Delphi, Thebes, Orchomenos—and to various Aegean isles—Melos, Thera, Delos—and to northwest Asia Minor, where at Troy Schliemann in 1870 began his reconstruction of its latest cultural phase, which we still call the Mycenaean Age. This culture had lain hidden from the time when the Hellenes first occupied the lower end of the Balkan peninsula in the second millennium B.C., to our time, a culture only dimly adumbrated by the Homeric poems and Greek folklore and regarded by historians till two generations ago as legendary. And we are still appraising the Greek debt to this Aegean empire.

Since the world war more significant advances have been made in our knowledge of Egypt, Syria, Palestine, Iraq and Persia, which allow us better to understand the immense antiquity of Oriental civilization and the debt of the Greeks and us to it. For excavations have made it increasingly evident that "Western Civilization" is, as V. Gordon Childe has recently phrased it, "but the culmination of a tradition of inventions and discoveries that is ultimately rooted in the Ancient East," whose culture on Nile and Tigris-Euphrates goes back some sixty centuries, as a brief survey of recent finds especially in Egypt, Mesopotamia and India will make clear.

After Howard Carter's discovery in 1922 of Tutenkhamon's tomb in the Valley of the Kings, in the desert opposite Thebes, which brought to light the most sumptuous funerary furniture ever

found, we expected nothing more spectacular from the Valley of the Nile. Since then, however, the last chapter in the story of Egypt has been written, really the first, for it is concerned with the remains found in graves of the Neolithic era. Now for the first time we have real knowledge of predynastic Egypt, the long prehistoric period before Menes, the first of the pharaohs, in the thirty-fifth century B.C. unified Upper and Lower Egypt under one crown. Previous to 1895 Egyptian records did not antedate the Pyramid Age—the third and succeeding few dynasties extending from the thirtieth to the twenty-fifth century B.C. Later, the French explorers de Morgan and Amélanau discovered tombs of the first dynasty, and still later the English Egyptologist Flinders Petrie laid bare some prehistoric graves. More recently, however, Neolithic remains have been found along the Lower and Middle Nile, whose different cultures are named from the sites there excavated—Merimdian from the western edge of the Delta, a culture which seems to have been akin to the Neolithic of South Crete; Badarian uncovered in 1924, and Tasian, both from the eastern bank of the Nile; and still other remains in the Fayûm. The area east of the Middle Nile was then a marshland with forests rather than a desert as in historical times. Tasian is the oldest culture yet unearthed in Egypt, and all three mentioned are the only Neolithic remains yet found and are certainly older than any already known in Europe.

In Mesopotamia Woolley in 1924 found an inscription of A-anni-padda, the son of Mes-anni-padda, the founder of the first dynasty of Ur, or the third dynasty after the Flood as reckoned by native historians. A little later evidence of the older first dynasty of Kish, the first after the Flood, was found and the weapons and implements of these early times showed that a high level of culture was attained here near the close of the fourth millennium B.C. Woolley's further discovery of the royal tombs of Ur in 1928, and evidence of a still earlier local Sumerian flood, whose echoes were brought back to Palestine by the Jews of the later Babylonian Captivity, who, in their account incorporated into Genesis, regarded it as mundane in scope, were as remarkable as Evans' discovery of the Aegean culture of Crete or Schliemann's unearthing of the later Mycenaean. For all these discoveries made it clear that by the close of the fourth millennium B.C. or earlier, a highly trained people here in Western Asia worked in copper and gold long before the Neolithic lake-dwellers of North Italy and Switzerland were building their wattled huts on piles with the aid only of flint implements. Still older prehistoric finds have been discovered by Woolley at Tell al'Ubaid in 1922, by Langdon at Jemdet Nasr near Kish—and later at Kish itself—in 1926, and by German excavators at Erech (Warka) in 1930. The latter, known as "Uruk culture" is midway in time between the other two. These finds disclosed the use of the potter's wheel, and showed that the lower Tigris-Euphrates valley was one of the oldest centers of civilization. More recently truly astonishing finds have been made by Dr. Speiser and the American School of Oriental Research on the site of Tepe Gawra near the ruins of Dur-Sharrukin (Sargonburg) in Assyria. This site, ever since its discovery ten years ago, with its twenty-three strata reaching back to the Painted Pottery People of an unknown Neolithic antiquity, has been rightly regarded as one of basic importance for the cultural history of the most ancient East. By 1937 two thirds of the area of the mound down to and including part of level XVI with its underground kilns have been excavated. Especially noteworthy is the rich culture of level XIII with its acropolis and buildings of

the Ubaid era of Sumeria, which represents one of the earliest known stages in the civilization of mankind, since it can not be later than the close of the fifth millennium B.C.

Nearly as astonishing were the finds from the ruined cities of Northwest India —Harappa on the Ravi and Mohenjodaro on the Indus, which were first published in 1924 by Sir John Marshall, and more fully in 1932 in the work of the same scholar and his collaborators entitled "Mohenjodaro and the Indus Civilization." These show that this part of India, first known to Western historians through Alexander's raid in the twenties of the fourth century B.C., was the seat of a notable culture at least as early as 2800 B.C., centuries before the advent of the Indo-European Hindus, a culture known to have had vital connections with that of Sumeria.

We are not here concerned, however, with these prehistoric and early historical periods, but rather with the developed cultures of the Near East. Here, in the long range of time from the beginnings of dynastic Egypt and the early city-states of Sumeria and Crete down to the passing of the last Oriental empire, Persia, we find astonishing advances were made in many phases of culture, such as government on a big scale, organized religions, codes of law, and, above all, progress in the mechanic arts especially in Egypt. These nations may be said to have made the beginnings and early stages in many fields, some of which were later perfected by the Greeks. They developed the first industries, such as weaving, metal and glass work, pottery, and paper, and they fashioned tools of bronze and later of iron.

The most astonishing advances in the mechanic arts were made by Egyptian engineers in quarrying, shaping, transporting and erecting huge weights of stone, and carving them with hieroglyphics. We need only mention the columns of the hypostyle hall at Karnak still standing to a height of nearly seventy feet, on whose capitals one hundred men could find standing room; the twin monolithic portrait-colossi of the seated Pharaoh Amenhotep III opposite Thebes in Upper Egypt, which, on a pedestal thirteen feet high, originally reached sixty-nine feet; the four colossi of Rameses the Great sixty-five feet in height hewn out of the native cliff over the Nile at Abou Symbel in Nubia; and the granite obelisk of Queen Hatshepsut, the first great woman of history, still standing amid the ruins of Thebes ninety-seven and one half feet high and weighing three hundred and fifty tons. An inscription on the base of the latter tells us that it was quarried, shaped, transported and placed into position in eight months! What granite works in our time with modern equipment would undertake to duplicate such a feat in twice the time? We may say that the Egyptians began and developed stone architecture, as well as sculpture and wall-painting.

Both Egyptians and Sumerians invented writing before the middle of the fourth millennium B.C., an art which has preserved many types of their literature —epic, dramatic, historical, epistolary, religious and scientific. The Egyptians invented a solar calendar as early, perhaps, as 4236 B.C.—called the first date in history—which with changes made nearly forty-two centuries later by Julius Caesar in 45 B.C. and fifty-seven later by Pope Gregory XIII in 1582 still serves the modern world. But we still get our divisions of time into months, weeks, days, hours and minutes from Babylonia.

Irrigation on the modern scale was practiced both in Egypt and Sumeria in the earliest days. The prehistoric canals built by the Sumerians made of their country a fertile and flourishing land down to the time of Hulagu, the grandson of the Tartar conqueror Jenghiz Khan, who destroyed them on capturing Bagdad in 1258 and left the plain of Shinar a desert to this day. The extent of Oriental navigation is illustrated by one achievement, the circumnavigation

of Africa by Phoenician sailors in the employ of Necho, one of the last of the pharaohs, twenty-one centuries before Vasco da Gama. By 1900 B.C., the Babylonians had developed a law-code which antedated that of Moses by centuries—a boon which we Americans do not yet possess. The Persians built one of the earliest of roads, the "Royal Road" from Susa northwest to Sardes, with ferries, bridges, milestones, and inns, over whose length of some fifteen-hundred miles their couriers with relays of horses carried despatches in six days, while ordinary foot-travelers required nearly three months. This was the quickest time down to the introduction of railways a century ago. To-day there are no railways in Persia yet completed, and only a single line in Iraq. Only since the world war has the 500 mile journey from Damascus to Bagdad across the Syrian Desert been shortened from seventeen days, the time taken by the Turkish camel couriers, to about twenty-five hours by auto-bus!

These are only a few of the important things done in the Orient before the rise of the Greeks. Unfortunately, however, we find side by side with these undoubted achievements just as noticeable defects. All Oriental governments, on however vast a scale administered, were invariably after one autocratic pattern of hereditary despotism. The great nobles who acted as ministers of the Great King merely administered the will of their master. Their monarchs were regarded as gods and the people never evolved any idea of democratic rule, responsibility of citizenship, patriotism or freedom. Their social structures were similarly unchanging, early crystallizing into fixed and immobile forms in which the people displayed no curiosity nor made any scientific progress beyond the beginnings of astronomy (and its handmaiden simple mathematics) and perhaps medicine. Their religions, with the exception of Zoroastrianism and Judaism, however well organized with temples, priestly castes, and sacred writings, demanded unswerving subjection to priest and tradition and some of them fostered cruelty and even lust. Outside a few individuals, such as Ikhnaton in Egypt, the first monotheist, Zoroaster in Persia, the founder of a dualistic faith which influenced Judaism and through it our own religion far more than is generally known, and the Jewish prophets, no one was able to break through the fetters of traditional belief.

Art early became more or less mummified through adherence to fixed patterns. It delighted in the colossal and impressive rather than in the beautiful whether in temples, tombs, palaces, statues or obelisks. All lacked the Greek *sophrosyne* or moderation, which made the Oriental peoples incapable of imagining a Parthenon or a Hermes. Even mythology was on a grand scale, sometimes developing into the grotesque as in the story of the Pharaoh Menkaure, who doubled his allotted time on earth by turning night into day. Only in morality do we find reasonable standards. Thus Maspero said the profession of faith in the Egyptian "Repudiation of Sins" was "among the noblest bequeathed to us by the ancient world." Zoroaster taught men a choice of conduct between good and evil, and among the Jews man was believed to be fashioned in the image of Jahweh.

Even the last and, in many ways, the best of these Oriental states, Persia, whose foundation and prosperity were coëval with the Greeks just before the latter's apex of culture in the fifth century B.C., showed little advance over its predecessors, despite the fact that it enjoyed the fruits of their experience of centuries. Its government was of the usual absolute type, though its twenty or more satrapies extending from the Mediterranean to India and from the Black and Caspian seas to the Second Cataract of the Nile and the Indian Ocean covered an area two thirds that of the United States and supported a population well over half of the latter's. However, Per-

sia was the first splendid attempt to organize many races under a centralized government which was strong and equable. Following the example of Assyria and Chaldaea whose political machinery she inherited, Persia allowed some local autonomy and some equality of rights for certain classes of her teeming millions. This was a difficult problem in so polyglot a realm and with such an imperfect system of intercommunication, and yet she made some advances in its solution. Founded by Cyrus the Great, who as vassal prince overthrew the Median Empire in 553–550 B.C., its administrative system was perfected by its third king, Darius, also rightly called "The Great" (522–485 B.C.), since his is one of the best examples in all history of perfecting imperial administration on a grand scale. His system, despite the weakness of his successors, when expansion, the very life of an Oriental state, was replaced by satiety, endured still for nearly two centuries until it was destroyed by the Greek conqueror Alexander the Great. And much of the Persian system survived later—especially in the orientalized Eastern Roman Empire ruled for centuries from Constantinople, and still later under the Saracens and Turks, for it was the best that Asia had produced.

Despite her advances in government, Persia knew as little of liberty as any of her predecessors. Her government throughout remained an autocracy, the Great King ruling, as we can still read on Darius' inscription in cuneiform on the lofty rock of Behistun, "by the grace of Ahuramazda"—the god of light whose viceregent on earth he was. The monarch was tolerant only so long as the satraps fulfilled their duties by aiding in war and paying tribute to Babylon. In spite of some degree of autonomy the satrapies were merely parts of a vast despotism, the land being divided into great estates between the nobles and the temples. Civil and military power was indeed divided between satrap or governor and army commander, as in the later Roman Empire from the time of Diocletian and Constantine, so that both were responsible directly to the Great King. But the satrap's loyalty was ever under suspicion; he was watched not only by the sectional commander, but by a resident secretary, "the King's Ear," who kept the king informed, and, worst of all, by royal traveling inspectors, "the King's Eyes," who spied on both. In such a state, however smoothly governed, there was no chance to develop anything like liberty, and the Persians seem not to have known the concept. For here as elsewhère in the Near East for centuries the people were slaves who did the master's will without protest.

We have said enough to show that one thing was lacking in every one of these Oriental states,—the idea of liberty, political, social, economic, religious. We can find hardly a hint of any such idea from the Sumerian city-states onward to the colossus of Persia. As Hegel, in his "Philosophy of History," has said: "They [the Orientals] only know that one is free" and "the consciousness of freedom first arose among the Greeks." The idea was even absent from the Jews from whose sacred writings we get the beautiful sentiment which can still be read on our Liberty Bell in Independence Hall: "Proclaim Liberty throughout the land unto all the inhabitants thereof." But in its context in *Leviticus* (25, 10) this refers not to liberty in any general sense, but only to freeing the slaves in the fiftieth year of jubilee. Liberty, therefore, formed no part of the Greek inheritance from the Near East. In fact its absence there made the Greeks ever contemptuous of the Orientals, whom they regarded as servile and unmanly. Liberty, then, grew up not in Asia nor Africa, but in Europe among the Greeks whose whole cultural activity was directly motivated by it. For individuality constituted the very center of the Greek character.

Why the Greeks developed ideas so different from those prevalent in the East—

originality, variety, curiosity, sweet reasonableness, and above all independence and liberty—features also appearing in the late Romans and revered ever since, it is impossible to say. Earlier writers tried to account for it, in part at least, by geographical conditions. Thus they liked to contrast the physical features of the Balkan peninsula, in which Hellenic civilization evolved, with those of Western Asia. They pointed out that, though the cradles of culture were the confined valleys of the Nile and the Tigris-Euphrates, still it was the vast plains of Asia, unbroken by natural boundaries and enjoying similar climate and products, which by their very configuration made the powerful Oriental empires possible with their uniformity of culture almost excluding change; and that Greece, on the other hand, broken into tiny valleys by intersecting ranges of hills and surrounded on three sides by the sea, whose gulfs and bays penetrate far into the land and make natural communications, was predestined to just the opposite—variety in climate, products, occupations, governments, and consequently in all phases of culture. Thus Wordsworth, in his Sonnet on "England and Switzerland," calls the mountains and seas the "Voices of Liberty" in these lines:

> "Two voices are here; one is of the sea,
> One of the mountains, each a mighty voice.
> In both from age to age didst thou rejoice,
> They were thy chosen music, liberty."

We need, however, only remember the dictum of Hegel, that geography is a conditioning and not a determining factor in the history of peoples. The Greeks loved their mountains and seas and owed much, but not all, to them. Probably they would have evolved the same genius equally well if situated elsewhere than in the Balkans. The modern Greeks live in the same environment, but after a century of independence have shown little approach toward the Periclean standard. It is as hard to explain genius in peoples as in individuals. We need only accept the fact of the Greek genius and its immense consequences to later Europe. To have "invented" liberty, as I like to term it, is, to my mind, the greatest thing the Greeks did or could have done, beside which all their other achievements in thought, art and literature, however remarkable, were secondary. More truly these things grew directly out of their inborn feeling of freedom. But we must also add that without the sustaining strength and genius for practical politics of the later Romans, the Greek idea of liberty, like many other good things for which we are indebted to the Graeco-Roman world, might have been lost literally, and a "new birth of freedom" might have been necessary in a later age. To this greatest of ideas, then, the Orient with its autocratic governments, submissive populations, slavish superstitions, and intellectual bondage contributed absolutely nothing. This alone, the appearance of liberty among them, should be reason enough, it would seem, why we should still know the Greeks and the golden treasures stored up in their beautiful language. For in order to understand ourselves and our own achievements we must know whence and how the initial impulse to Western progress has come.

Liberty, then, was the supreme gift of the Greeks to European culture. This alone will help us to explain many of the encomia on Greece expressed by philosophers, poets and scholars. It will explain why Hegel a century ago spoke of Greece as "that point of light in history"; why Shelley in his "Preface to Hellas" said, if with some exaggeration, "we are all Greeks. Our laws, our literature, our religion, our art, have their roots in Greece"; and why Sir Henry Maine, in his work on "Ancient Law," said "Except the blind forces of nature, there is nothing that moves in the world to-day that is not Greek in origin." We first see the idea dimly adumbrated in the council of chiefs before Troy as described by Homer, but the germ was

older, doubtless brought into the peninsula of Greece from the grasslands of the Danube by the ancestors of the historical Greeks who perfected it. Our whole idea of democracy has come directly from its completion in the "Demos" of Athens, long heard from the open-air assembly on the Pnyx.

Liberty was the mainspring of every phase of Greek culture. Out of it arose the Greek city-state, the only political unit freely accepted by the race down to the extinction of their independence by Macedonia, a unit which, despite its small size and narrow outlook, met their ideal of a population of independent citizens rather than of subjects. Any attempt on the part of one such unit to coerce the rest, as was made by Athens, Sparta and Thebes in succession, was regarded as an outrage against their innate notion of freedom. Its infractions by Athens caused the most melancholy war of antiquity, the twenty-seven years struggle between her and Sparta. Out of the city-state arose the democratic and self-governing spirit of Greece, an ideal still reverenced in many parts of the world. It was the same spirit of freedom which kept Greek religion from dogmas, traditional creeds, infallible revelations and sacerdotalism. They felt that these things would hamper their curiosity and freedom of thought. While the Oriental religions soon crystalized into institutionalism, that of the Greeks helped to make them free and happy. Its unique characteristic was, as Jane Harrison long ago pointed out, freedom from fear, which is a lever habitually used by all other religions. The Greeks regarded speculation as an attribute of the godhead. The goal of their religion was not the practical one of keeping people submissive, but was purely speculative. Freedom also kept the Greeks from tabus and asceticism, for their religion allowed them a sane use of nature's gifts. Their morality, like other features of their lives, was governed by "moderation." Greek ethics was a social and not a religious phenomenon, and the two, ethics and religion, were kept separate and not joined as in other faiths. There was no divine sanction to their rules of conduct, for such rules were the work of human teachers, such as Socrates. Their simple ethics freed them from any deep sense of sin or fanaticism for unattainable perfection. The Greek accepted life, lived here and now, and was little concerned with doctrines of immortality. He hated death as much as we Christians do—but for a different reason. He hated it, but did not fear it.

In their city-state experience which extended over centuries the Greeks came to know most of the historic types of government. Athens, their greatest city, alone in her long story from the prehistoric blending of Ionians and autochthonous native stock down to the time of Alexander the Great, experienced most of these in succession—monarchy, aristocracy, timocracy, tyranny or dictatorship, democracy, imperialism, oligarchy (the "Thirty Tyrants"), and, finally, she with her sister states formed a fragment of Alexander's world-empire, which was founded on their ruin as well as on that of Persia. About the only types of rule she did not know were absolutism and the modern ideas of sovietism and fascism, though Athens and other Greek states in the fourth century B.C. reverenced the "strong man" in politics, in one of whom, Alexander, the whole race finally found its hero. With his vision of a vast world-state Alexander not only transcended the provincialism of the Greek city-state, but the nationalism of his own Macedonia as well. For, while extending Greek culture as the leaven of his new state he at the same time, seemingly unwittingly, destroyed Greek liberty, which had been, as we have seen, its motive power.

Many of the basic political and social ideas of the modern world are ultimately inherited from Greece. We need only mention democracy, aristocracy, representation, political parties and clubs, annual magistrates, "recall of judges" and

impeachment, senates, assemblies, councils, committees and commissions, legislation, constitutions, premiers, demagogues and politicians, the ballot, lot, popular courts, federation (the "Hellenic Leagues") and imperialism. Ostracism or temporary banishment without specific cause we know only by name, but we might use it to advantage in curtailing the power of unscrupulous demagogues. All these things are Greek. Even the Greek city-state itself survives in a larger framework. Its only solution in antiquity was the Roman Empire, whose municipalities corresponded with the Greek units. And these have survived to our time.

Not only did the Greeks in their political and social life have actual experience of liberty, but they were the first to theorize about it. In the words of a recent historian "they wrote the first chapter in human liberty." When we consider how diminutive and narrow the Greek city-state was, we are amazed at the permanency and modernity of the political thought which grew out of it. With the Greek neglect of certain problems which bulk large in our politics—*e.g.*, foreign relations, and their emphasis on others—*e.g.*, the absolute authority of the state over its citizens, it would seem that the Greeks could have little of importance to tell the modern world with its huge cosmopolitan political units.

And yet Greek political ideas, expressed from the time of the sophists in the late fifth century B.C. onward, influenced first the Romans, then the Middle Ages, and finally early modern thinkers to the close of the eighteenth century, and still interest us in the twentieth. In fact one can hardly understand early modern political ideas without some knowledge of their Greek background—such theories as those of natural law, human equality, the ethics of justice as the basis of states, private property, slavery. All these and many more were Hellenic concepts first discussed by Greek thinkers. The Stoic doctrine of universal brotherhood, of an ideal world without distinctions of class, sex or family ties, have played along with Stoic ethics an immense role in Christianity.

In a word the Greeks created the science and theory of politics. They were the first to reason about law, equality, justice, natural rights, and, above all, liberty and how to attain them. They have given political and social science not only its terminology, but largely its content. They thought about the state—its nature and function, the advantages of this and that type of government, the relationship between the state and its citizens, law, education and religion in the state, the right balance between individual liberty and the authority of the state, the distribution of wealth, slavery, and many other problems.

Curiously, it was chiefly in the fourth century B.C. during the political decay of the city-state that political and social thinking reached its height in the two greatest of Greek thinkers—Plato (427–346 B.C.) and his pupil Aristotle (384–322 B.C.). We shall close this essay, therefore, with a brief survey of their political thought. Plato lived through most of the tragic Peloponnesian War (431–404 B.C.), and at twenty-three witnessed the downfall of his native Athens at the hands of the Spartan victors, and the subsequent tyranny of the Thirty Tyrants. Throughout the first half of the following century he witnessed the strife of the city-states down to the beginning of the menace of Macedonia. Such an experience naturally affected his writings. Born of aristocratic lineage he refrained from participating in his city's politics, alienated by the misdeeds of the Thirty and especially by the martyrdom of his teacher Socrates in 399, when he was only twenty-eight. Suspicious of democracy and amid the disintegration of government and religion he turned to philosophy. In his "Dialogs" he discussed many themes—psychology, metaphysics, ethics, mathematics, justice, religion, grammar, rhetoric, logic, educa-

tion, and, above all, theories of government and society. These latter appear for the most part in his masterpiece, the "Republic," whose central theme, the nature of justice which he regarded as the true goal of society and the state, for it alone could bring happiness to all, led him to conceive an ideal state based on education. In fact, he believed that education, music for the mind and gymnastics for the body, was the true function of the state. It occupies so much space in his ideal state that Rousseau said "the Republic is not a work on politics, but the first treatise on education ever written." In his last work, the "Laws," while keeping his earlier ideas on art, trade and finance, he abandoned most of his more Eutopian ones and conceived a more practical state with ideas better adapted to real men. To his pupil Aristotle he left what did not appeal to his idealistic nature—experimental science.

Aristotle, in the Middle Ages revered by the schoolmen who curiously accepted him as the "master of those who know," was born in Macedonia, but lived most of his life in Athens. For a score of years before Plato's death he was student or assistant at the latter's Academy. Then, after several years in Macedonia as tutor to young Alexander, he returned to his adopted city and there opened his own school, the Lyceum, on the slopes of Lycabettus, which he conducted till his exile and death in Chalcis. During his lifetime the greatness of Athens had vanished, but he seems to have evinced little interest in it. His manhood coincided with the chaotic period extending from the death of Epaminondas in 362 B.C. to the almost complete extinction of the city-state liberties at Chaeronea at the hands of Philip in 338 B.C. He lived on through the period of his pupil's conquests and died a year after the young conqueror. Thus, like Plato, he enjoyed a varied experience in politics, though he curiously seems to have been little disturbed by the momentous changes which he witnessed. With his vast learning he organized most of existing knowledge. In addition to writing on many of the topics treated by his master, he also wrote on physics, anatomy and especially zoology, as well as constitutional history, literary criticism and politics. While keeping his independence his works show the influence of Plato, just as the latter in his "Dialogs" shows that of his master Socrates.

The "Ethics" and its sequel the "Politics" are the most important of his works to us. The latter may be called his masterpiece, comparable with Plato's "Republic," and has long been known to English readers in Jowett's translation. It is based on over one hundred and fifty city-state constitutions—even including one of Carthage—apparently compiled by his pupils, only one of which, the "Constitution of Athens," has survived, found on a palimpsest discovered in 1890, and is in effect a critical summary of the political experience of Hellas. While less universal than his master, he is by far the most modern in spirit of any Greek philosopher.

In many ways these two, as would be expected of master and pupil, share similar views of politics and society, while in other respects their thought was diametrically opposed. Both based their thinking on the *Polis* or city-state, which already had passed its usefulness. Indeed Plato's "Republic" has been called by a recent writer not only the *apotheosis*, but the *reductio ad absurdum* of the *Polis*. If this is difficult to understand in so universal a thinker as Plato, who died before Chaeronea, it seems incredible in Aristotle, who lived through the conquest of Greece by Philip and that of Persia by his son Alexander. Still he seems to show little interest in the political changes wrought by Alexander and certainly none in his world-empire. His ideal was still the old city-state, though it had become an insignificant fragment in the new Macedonian monarchy.

Both thinkers followed the sophists in

assuming a natural origin of society as growing out of the mutual needs of mankind—*le contrat social* of Rousseau and other eighteenth century writers. Out of this need Plato derived his division of labor. Both emphasized the basic need of education, and both believed that the happiness of all was the function of the state—in Aristotle's words "a state exists for the sake of the good life," which he regarded as one not of power and wealth, but of virtue. While Plato regarded democracy as a form of license since it presupposed the rule of the least fitted, Aristotle regarded each of the three main types of Greek government—kingdom, aristocracy, republic—as advantageous under different conditions. While believing that monarchy or aristocracy was the best ideally, he believed that the only good practical government was one in which the middle class was supreme, while admitting that this "middle" form of government had rarely, if ever, existed.

Plato believed in communism for his upper class—the governors or "lovers of wisdom." They should hold no private property, their marriages should be supervised by the state, and their children, as in Sparta, should be brought up by the state. This was to give the governors leisure for affairs of state, and so Plato's communism differed greatly from the brand of our time, which aims to abolish poverty and to equalize wealth and is universal for the whole people. Plato was against all ideas of wealth with its contaminating influences. While sharing with his age and race in the belief in the natural inferiority of women, he nevertheless believed that with the proper qualifications they should have equal opportunities and training with the men and should be relieved of the care of children by the employment of public nurses. He believed that marriage should be based on eugenics, and, since he does not include slaves in his Republic, seems to have been against slavery.

Aristotle, on the other hand, criticizes his master's views on communism, for he believed in the retention of private property and the family and, in order to give the citizens leisure for higher development mentally and morally, that they might better perform their duties, he argued for the curtailment of trade and industry. Further he regarded women as inferior to men and slavery as a natural social need for the best life of the citizens, the slave being only an "animate instrument" predestined to his lot by nature itself. He also expressed the modern idea that the bad regulation of property and distribution of wealth was "the point on which all revolutions turn," and believed that the false notion of equality and the lack of balance in society were due to the decadence of the middle class which should act as a mean between rich and poor.

While Plato was interested in formulating his ideas by imagining an ideal state, the first Utopia or ideal society in the history of political thought, Aristotle was interested rather in the attempt to understand the nature of the state by analyzing its various types and constitutions and finding which was best fitted for each. And while Plato believed that rank and service should come from mental and moral capacity, Aristotle thought that there should be no absolute equality, but one proportioned to the contribution of each citizen to the general welfare. By leaving offices open to all without pay he imagined that only the best citizens would fill them.

Enough has been said in this imperfect review to show the depth and modernity of many of the theories of these two great thinkers, the supreme interpreters of many phases of Hellenic thought, and their influence on political and social thought down to our time. And enough has been said also to show that our ideas of political liberty both in practice and theory go back to the Greeks and to no other people.

EPIC OF LIFE

By Dr. OSCAR RIDDLE

CARNEGIE INSTITUTION OF WASHINGTON, STATION FOR EXPERIMENTAL EVOLUTION, COLD SPRING HARBOR, N. Y.

It is only recently that the human mind has grasped the bold outlines of its own history and that of life on the earth. This triumph of unceasing inquiry into the nature of man and man's place in nature now lifts human beings a grade higher in the scale of living things. The many fragments of this long story of life rest securely in scores of volumes—the tributes of a dozen sciences. Can the contour and import of these many scattered fragments be fitted into a few pages? An answer is attempted in the following paragraphs.

The whole of the drama of life seems to have been performed in a very restricted zone—quite near to the very surface of our small planet. Even bacteria disappear in the upper reaches of the atmosphere, and other life extends downward only to the limits set by the ocean depths. At no earlier time in the earth's history has this been different. Fossil remains of living things are found in coal and rock strata now a few thousand feet beneath the soil on which we walk, but it is clear that these veins were land surfaces or ocean floors when they trapped the dead bodies of organisms. If we could look at the present living world from afar, say from the 24,000 miles, which is one tenth of the distance to the moon, we could rightly sense the narrow pinions of life. On the great sphere which would nearly fill our view to east or west we should then see all life imprisoned in a thin film—a living skin—tightly fitted to the very surface of the earth. As we now know it the entire story of life sticks to the place where there is liquid water; where gaseous oxygen, carbon dioxide and nitrogen abound; and where surfaces can absorb sunlight for a continuous flow of free energy.

Though the story of life is narrowly limited in locality or space it plainly fills an amazing lapse of time, and the year is an inconveniently small unit for reckoning its more significant chapters. Probably longest of all its long chapters was the period involved in forming those minerals and in attaining those conditions of temperature and moisture on the earth's surface which would lead to the building of the first and simplest living matter. When the huge quantity of earth-building material was first split off from the hot sun its temperature, mass and gaseous state gave assurance that hundreds of millions of years must elapse before conditions favorable to the origin of life could exist upon its surface. After its separation from the sun this gaseous matter cooled much faster than before, and although very few chemical compounds could exist in the superheated gases of either the sun or the new-born earth many such compounds were formed while the isolated earth slowly acquired lower temperatures. The formation of this great variety of new chemical substances was essential to the origin of life and also to its maintenance after it had arisen. Mixtures of extremely hot gases such as exist in the sun can not undergo cooling to earth temperatures without chemical union, and some of these stable and durable combinations of heated gases are still being effected within the hot volcanoes of the earth to-day.

When the earth became cool enough to permit water in the liquid state to remain on its surface, this earth of ours not only surrendered to the agent which would thereafter dominate and repeatedly remould its surface—and eventually destroy its daily rotation by tidal action—but it passively built the cradle for life.

Forever thereafter water would accumulate in smaller and larger amounts in millions of pools; and always thereafter water would leach some chemical compounds from the diversified rocks, thus giving these compounds opportunity for ever new interactions in that unrivalled chemical laboratory—an aqueous solution. The forces that chilled a burning earth and formed its first pool of water also decreed that innumerable new combinations of matter—each combination with new properties—would appear on the surface of this planet.

In an almost equally significant way the gases which remained on this cooled earth, together with the sunlight which now became a sole and intermittent source of light and energy, assured a still greater variety of new chemical transformations—because these gases and light rays actively invade water. Under the superlatively favorable conditions of an aqueous medium, and for the first time in all our planetary history, these active agents of the air began their unending work on the water-held leachings of the rocks. Included in the earth's early atmosphere was a great store of prying active free oxygen; other oxygen which had tied carbon to itself and yet maintained the free and gaseous state as carbon dioxide; some hydrogen and rarer gases; and finally, a vast store of passive nitrogen—the nitrogen which had proved so largely immune to imprisonment in the great rock which is the earth, the nitrogen which still awaited the rendezvous at the pool—the water crucible—for nuptials with subtler compounds whose issue would exhibit the properties of life.

The next step in the long march of life attained the formation of organic matter from the plenitude of inorganic compounds and gases already accumulated. Probably in more generous quantity than now the surface of the youthful earth released a simple but very reactive gas, hydrocyanic acid, or HCN. This gas, then as now, on dissolving in water gave rise to many organic and nitrogen-containing substances—such as urea and the amino acid, alanine. From still other sources various organic substances were produced. The action of sunlight on carbon dioxide dissolved in water almost certainly gave rise to formaldehyde, sugars and other organic substance long before any microscopic particle even partially endowed with life arose in the pools and ooze of a warm young earth. Just as they seem still to do this in our time the colored surfaces of some flinty water-cups of a naked earth increased the rate at which the sun's rays built organic substances from carbon dioxide and water. The formaldehyde formed in this way could unite with the nitrate or nitrite dissolved from certain rocks and thus produce the very reactive nitrogenous substance, formhydroxamic acid; this acid, plus additional active formaldehyde, must then have produced a whole series of substances which are to-day the commonest constituents of plants and animals—purine, pyridine and amino acids.

With the creation of amino acids a further step could be taken toward the formation of fragments of brevetted matter—matter alive or partly alive. These amino acids are the blocks from which protein is built, and to this day all living matter is built chiefly of protein. Each molecule or building-block of amino acid has behavior and endowments—chemical and physical properties—which differ from those of any other kind of molecule. Such building-blocks can be put together in an almost endless variety of ways, with each new way yielding a new and different protein—and each new protein having one or more properties possessed by no other grouping of matter. Though nearly or quite two million living species now exist, each with one or more proteins peculiar to itself, probably no more than twenty-five different building-blocks are used in the construction of these millions of different proteins.

With the formation of protein molecules our earth was at the threshold of life. The viruses which cause such things

as colds in humans and mosaic disease in tobacco and asters, are particles of matter too small to be seen with any existing microscope. They are, however, probably pure proteins—and they possess one and only one of the properties of living matter. Under certain conditions they can divide and very exactly reproduce themselves. Though the virus may be said to be only "half-alive," it can be killed; but man, willow, worm and bacteria are killed far more easily. Again, those similarly minute and unseeable particles which in all living things bear the hereditary qualities—the genes—are in several respects similar to virus molecules. Probably both kinds of molecules are proteins; they are of about the same size; they both show a rare and peculiar form of instability or tendency to mutate; and both are able to reproduce themselves only when in contact with larger and more complex molecular aggregates which show all the properties of life. Probably no single gene standing alone is fully alive; but many genes are packed closely together in all living cells, and since the various genes of a cell differ somewhat from each other their very juxtaposition or aggregation may add other elements of "liveness" to the aggregate. All really intimate unions of molecules are known to create properties not present in the uniting components; and gradations in "liveness" do exist. With these developments centering about endless labile compounds of carbon and nitrogen the phase of living substance may be said to begin, and the inconceivably long era that began with a few hot and mutually repellent gases in a burning fragment of the sun was ended.

It was also a very long way from the simplest living cell to the man of a million years ago. But this long way was all the trail and unbroken chain of life, and since man has learned the cogent rule of that extended highway its course can now be roughly charted. In the great lapse of time the many genes within the simple single cells were able now and again to add new genes to the old store. Here each new gene meant a new type of cell—eventually a new race or species if the conditions into which it was born permitted it to live and reproduce. In still other cases cells ceased to separate after their division or reproduction, and the resulting aggregates—these groups of cells—gave rise to several sponge-like animals.

No event in the history of life is more notable than the earliest and unwitnessed case of dividing cells remaining attached to each other, getting mutual benefit from it and preserving this state through all later cell generations. Few of the many primitive single-celled species accomplished this; but those that did provided the possibility for flower and fish and man. In these cell-communities, and also in the single cells which preceded them, there was occasional chance for offspring to start their lives with a set of genes which differed slightly from those of their parent or parents. By whatever means the genes were increased or were changed—and, in experiment, even x-rays have shared in causing genes to change—individuals and races of a new type were produced in that fraction of cases in which the changes were helpful; the luckless bearers of the still more numerous disadvantageous changes quickly disappeared without leaving descendants in the stream of life. Hundreds of millions of years provided many hundreds of thousands of advantageous hereditary changes; and many hundreds of thousands of superior species of plants and animals came to crowd and glorify the earth. Now and again during this period splendid species which had persisted for ages disappeared from the living scene, and their fossil remains tell of such things as changing climates and new enemies—things to which these once living forms could not adapt themselves.

One to five million years ago there were several very superior animal tribes with expanding brains, all assuming more or less upright positions and developing

skilful hands. Somewhere within or near this period one of these tribes markedly outstripped the others and its descendants became paleolithic man. The early performance of this man is not flattering to humanity in general, but probably we could not even approach an understanding of ourselves without some familiarity with this distant human ancestor. He and his neolithic successor reveal very much that is truly inborn and nakedly human—characteristics now much obscured in modern man by a capital thing called "social inheritance."

Primitive man required an unknown amount of time for learning to make a most simple tool—a flint for aid in obtaining food and subduing wild animals. But for hundreds of thousands of years thereafter this paleolithic man apparently made little further progress. Once he had made himself a bit safer from dangerous animals, and was assured of a somewhat readier food supply, he seems to have remained for thousands of generations almost as non-progressive as a population of black bears. If paleolithic and modern man could meet they would be quite incomprehensible to each other; but the milestones between the two ages and the two men tell much. Tool-using man has been doing something on some parts of the earth's surface for perhaps five hundred thousand years. Yet it is probably only within the last fifteen or twenty thousand years that he built his first city. Four hundred thousand years —tool-using man—but no city! A drab epoch of human futility; a brutal demonstration of primal limitations of raw untutored man!

Even the limitations of our somewhat more recent ancestors—those neoliths distant by no more than a thousand generations—are so evident as to require the consideration of factors elsewhere immaterial to the story of life. The man of to-day is or seems so different. How can we bridge the gap between him and his progenitors of thirty thousand years ago? That adjacent ancestor was probably equipped with nearly or quite as good heredity as are most men of to-day. Neither structural changes occurring in man nor changes in the genes carried by him, adequately account for the changes that have occurred in man during the last twenty or thirty thousand years. Those changes came largely from social forces born with an alliance with fire, the discovery and extension of agriculture, the invention of alphabets and wheels, the domestication of animals and the use of metals and harnessed energy. These external things—created doubtless by a clever few and shared by all—brought security, plenty and leisure; and they also supplied the foundations for written language, accumulated experience and able leadership. No human being thereafter grew up as his mere primate self, but from infancy onward he was permeated by much that his race had already accomplished—a thing not possible in any other living species and a thing scarcely evident in primitive man during some hundreds of thousands of years.

Thus the long trail of life leads to modern man—the winner of an age-long race between many brothers. Like the sparrows he arrives not as a single breed but as several. Though these races have not been physically blended by the external or social things of their own creation, they already begin to understand each other. In numbers far greater than at any preceding epoch the living bodies of man now caress the hemispheres. His art and labor have laid a friendly, fruitful, chequered sward upon a planet. His growing mind has gripped the sun, moon and a hidden universe of stars—and wrested speech from buried milestones of his own path of many million years. With the mantle of these triumphs about him modern man now exalts both himself and his hardy groping ancestor who painfully shaped a flint.

THE LAND AND THE PEOPLE

By H. H. BENNETT
CHIEF, SOIL CONSERVATION SERVICE, U. S. DEPARTMENT OF AGRICULTURE

DURING the decade since this country felt the first impact of world depression, public interest in the problem of land use has become more intense and realistic than it has ever been. Among other things, the depression set us to looking for the causes of economic distress in agriculture; and many of them we found to be rooted in a pattern of land use that was basically unsound. The experience of the depression convinced many people that the recovery and sustained welfare of agriculture would require a drastic renovation of our national land-use situation. The recognition of this need, coupled with dust storms, floods and other unmistakable physical signs of land abuse, has created a keen awareness of land problems in the public mind and brought a general public demand for positive steps toward land reform.

Through the normal processes of democratic government this demand has been translated into public programs of a kind that differ sharply from the traditional. In the past, public agencies relied principally upon research and education to solve the ills of agriculture. To-day, they have moved beyond these fields into the field of action, bringing the resources and facilities of the government into play directly on the land. The result has been to create a new situation, full of new opportunities for dealing with the varied and complex phases of the broad land problem.

Equally significant is the rapidly increasing interest of rural people in the matter of land reform. The inertia, or lack of interest, of the individual which for so long impeded agricultural action has disappeared to a large degree. As a result, agencies of the government engaged in land-use programs are now receiving intelligent cooperation from men who use the land day in and day out. There is a close working alliance between farmers and the government which did not exist a decade or so ago. To-day, the actual land users of the country are beginning to build their own programs of land-use readjustment out of their own grass-root experience. Through soil conservation districts, county planning committees, rural zoning groups and other democratic mechanisms of recent origin, our present-day problems of land-use are being studied and analyzed; action programs are being planned and carried out by farmers themselves with the help of public agencies especially equipped and authorized to assist them. In a very accurate sense of the term, this is land-use action from the ground up. One might say, in fact, that public land-use programs nowadays are *grown,* not *made,* since they spring directly from the land; and are carried out, in large part, by people to whom these needs are a matter of everyday concern.

As a result, it is now possible, through the cooperation of these local groups, to bring public action programs effectively onto the smallest unit of land use—the single field. This in itself is a highly significant fact. Public land-use action must, of course, be broken down into spheres—a national sphere, in which the primary concern is with the broadest realignments; a regional sphere in which readjustments must be made to fit the needs of major segments of the country; a problem area sphere, and so on. Ultimately, there is the smallest sphere—the field.

Attempts to plan and carry out rearrangements of national, regional or problem area land-use patterns will come to

naught unless it is possible to rearrange the pattern of land use on the individual acre of the individual farm.

A region may be unsuited to a given type of agriculture, but its agriculture can be changed only field by field. It may be that the size of farms must be readjusted in a given problem area, but still the readjustments can be made only field by field. The formation of local land-use action groups, empowered to cooperate directly with agencies of the government, federal or state, in formulating and executing plans for land-use reform, brings the public program effectively into this important final sphere of action.

Typical of this extremely interesting trend toward the assumption of land-use responsibility by local people is the growth of soil conservation districts during the last two years. In that relatively short time, twenty-six states have enacted legislation authorizing the formation of these local cooperative land-use organizations. As of November 15, 1938, 103 districts had been formed. These cover an aggregate area of some 54 million acres of privately owned farm and grazing land.

Details of the procedure involved in their creation under state laws are not relevant to this discussion. It will suffice to point out that they are formed voluntarily by groups of land operators for the specific purpose of readjusting and regulating land-use practices in the best interests of the community. The entire process of formation and administration is completely democratic, with ample opportunity for the expression of majority will at every important stage.

Stated simply, the function of the district is to develop and help land operators carry out a program of proper use for all the land within its boundaries. The district itself may undertake to carry out the work; or it may request the assistance

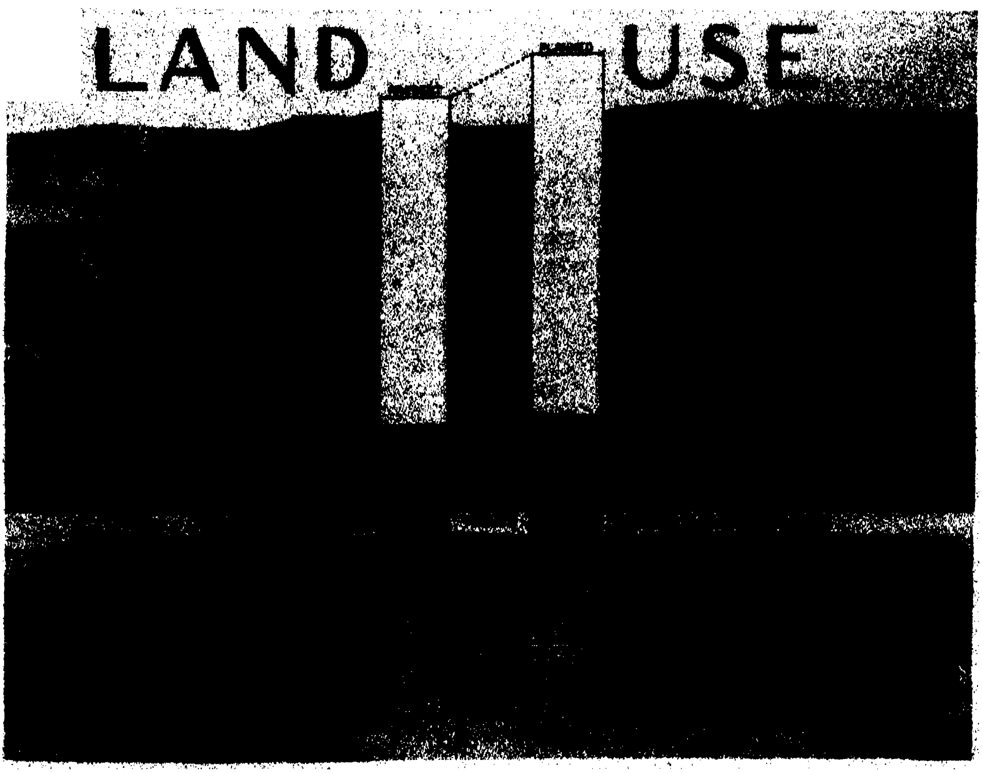


FIGURE 1

of the Soil Conservation Service and other action agencies of the government. Actually, the latter course is usually followed, since districts, in the beginning at least, seldom have the facilities for extensive reorganization of land use.

The program drawn up and proposed by a new district embracing five counties in north-central Georgia will indicate the part these local agencies are now taking in the national land-use picture.

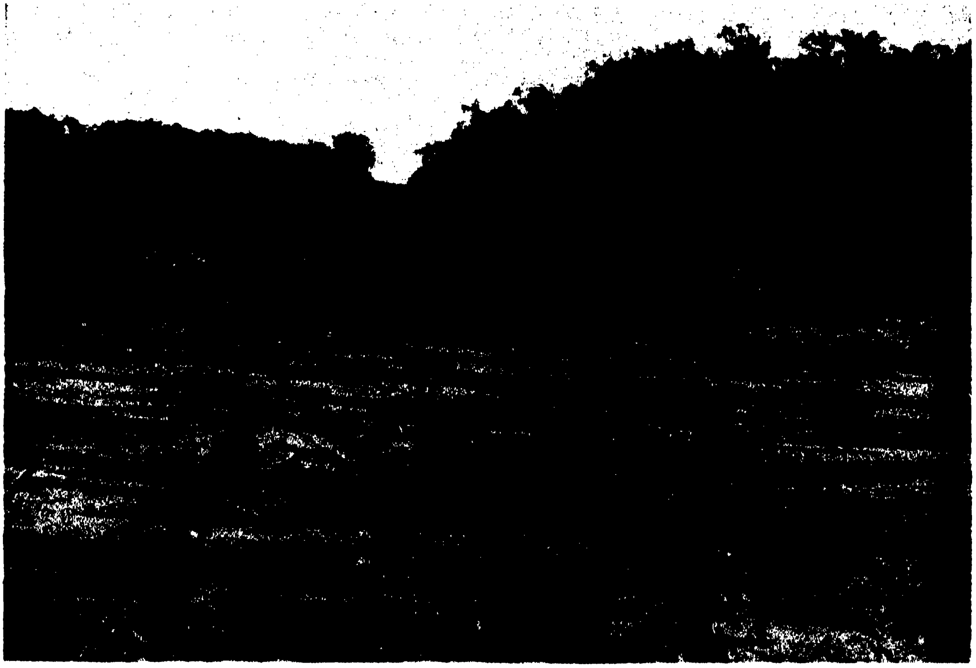
The declared objectives of the program of this district are in general to "enable farmers to raise and maintain a suitable standard of living and to perpetuate agricultural resources within the district." More specifically, the objectives are, first, to bring about the adoption of necessary practices for the conservation of soil resources; second, to make the adjustments necessary to a wise land-use program, such adjustments being directed toward an increased income for individual farmers; and third, to develop necessary land-management practices, such as would provide for the efficient utilization of extra feed and pasture resources resulting from the realignment of farm-cropping systems.

In approaching these objectives, this district proposes a number of land-use readjustments, including an increase in total crop land of approximately 12,500 acres; an increase in pasture land of approximately 7,500 acres; a decrease in woodland pasture of approximately 8,000 acres; a decrease in idle land of about 60,000 acres; the reforestation of some 30,000 acres of eroding land currently in crops; the purchase and development of approximately 200,000 acres of submarginal land; the rehabilitation of some 2,900 farmers through loans by the Farm Security Administration; the protection and improvement of 26,000 acres of farm woodlands; the development of food and cover for wildlife; and the installation of sound conservation practices, such as strip-cropping, terracing, cover cropping and planned rotations on all cultivated land vulnerable to erosion.

Into this district, at the specific request of the district supervisors, the Soil Conservation Service is bringing the facilities of a major public action program. It has the authority to assist in planning and applying soil-conservation measures on individual farms; in establishing good woodland and pasture-management practices; in reforesting or regrassing crop lands retired from cultivation; in purchasing the areas of submarginal land recommended for permanent retirement by the district, and so on. In other words, through alliance between the district, as an agency of the community, and the Service, which administers federal aids to better land use, the people of the five counties are given maximum public assistance in readjusting land use farm-by-farm. Public action is brought effectively into play in making single farm realignments and in fitting them into the larger pattern of desirable land use in the district as a whole.

The Soil Conservation Service is mentioned in this connection simply to illustrate the close and highly effective alliance which is now possible between public agencies and local people. There is no intended implication that the program of public aids administered by the Soil Conservation Service represents more than a partial answer to all problems of land use. Indeed, it seems apparent that no single type of public assistance is adequate to cope with those problems in all their ramifications.

But close cooperation between a number of public agencies now engaged directly or indirectly with the problem will have the effect of creating a single broad-gauge program adequate to help the people bring about most if not all of the necessary changes in our national land-use picture. Not all these agencies are part of the Department of Agriculture: The Indian Service, controlling vast areas of Indian land; the Division of Grazing, with authority over the public range; the General Land Office and the Park Service, are parts of the Depart-



DOWNHILL PLOWING INVITES EROSION

OF THIS IOWA FIELD. SOIL FROM THE UPPER PART OF THE SLOPE IS BURYING CROPS AT THE BOTTOM.

ment of the Interior. The work of the Farm Credit Administration, the Federal Housing Administration and many other governmental organizations bears a certain influence upon land use. All of them, as well as the Agricultural Adjustment Administration, the Bureau of Agricultural Economics, the Farm Security Administration, the Bureau of Public Roads, the Forest Service, the Soil Conservation Service, the Biological Survey and various other agencies of the Department of Agriculture must take a coordinate part in national land-use effort if the scope of that effort is to encompass all lands now ill-used and all the enormous ramifications of the problem. The activities of all these agencies and of various agencies of the states must merge, out on the land, into a line of action in which administrative divisions disappear, objectives coincide and methods harmonize.

Realistically, this is not an easy situation to bring about. But very tangible steps already have been made in the right direction. The relationship between many of these agencies is very close today; programs and objectives are mutually understood; distinctions based on purely administrative lines are rapidly disappearing, and there is every reason to believe that in general the activities of public agencies in the field of land use are better coordinated, more carefully adjusted to one another at the present time than they have ever been.

From the national standpoint, naturally, the Department of Agriculture occupies a predominantly important position in the field of land use.[1] Nearly every phase of the department's activity

[1] "The New Department of Agriculture"; address by M. L. Wilson, Undersecretary of Agriculture, before Texas Agricultural Workers Association, Fort Worth, Texas, January 13, 1939.

CONTOUR FARMING IN SOUTH CAROLINA

WHERE THOUSANDS OF ACRES HAVE BEEN SAFEGUARDED AGAINST EROSION BY TERRACING, STRIP CROPPING AND OTHER OPERATIONS ON THE CONTOUR OF THE LAND.

either directly or indirectly affects land use. The work of the Agricultural Adjustment Administration in the field of economic stabilization and agricultural conservation is a direct influence for better use of the land; the rural rehabilitation program of the Farm Security Administration likewise bears directly on these problems. So also does the work of the Forest Service in the management of national forest holdings and the work of various other departmental agencies in the fields of planning, research and education.

Most directly concerned with land-use problems on the vast bulk of privately owned agricultural land, however, is the Soil Conservation Service, which seeks, through several lines of work, to assist farmers in correcting the physical land practices contributing to land decline. The Service now administers activities involving the conservation of basic soil and water resources, the purchase and improvement of submarginal land areas, the promotion of farm forestry, the treatment of watershed lands for flood control and the development of farm and ranch water facilities in arid and semi-arid regions of the West.

Each of these lines of action is important in itself as a means of land-use readjustment. The adoption of sound soil-conservation practices on a farm or in a watershed suffering from severe erosion usually requires a realignment of present cropping and tillage methods. Frequently, these realignments, when carefully planned, result in a better economic status for the individual farmer and the community. The promotion of forestry as an integral part of the farm economy likewise changes the use of land. The purchase of submarginal areas and their development along lines properly suited to their use obviously affects the land-use pattern in any locality. Adequate facilities for stock water, irrigation and water spreading in the West make it possible to correct abusive grazing practices, improve the range and develop certain areas for the production of crops. In other words, in carrying out each of these several lines of action, patterns of land use actually are altered.

Combined into a single, integrated attack upon the diverse land-use problems of an area or a region, these several action programs constitute a rather well-rounded approach to the correction of the physical ills of the land.

An interesting example of the application of such an integrated program to a given area is the soil conservation demonstration project of the Service in the low-rainfall area of the Wind River Basin, in west-central Wyoming. Heavy overstocking of the range, and poor grazing management had brought about serious depletion of forage over much of the basin, resulting in severe erosion and the waste of water from denuded and eroding lands.

Some 45,000 acres known as the Riverton tract, in the Shoshone Indian reservation, were selected in 1936 for a demonstration of improved land-use possibilities. In this tract, originally well grassed, some 3,335 sheep were then being grazed under a lease management, along with about 500 trespass sheep. The only available water was that of Wind River, which for a short distance forms the extreme northwestern border of the tract. Because of this inadequate distribution of stock water, only about half the area was being utilized for grazing. Much of this was being so severely over-used that the productivity in animal units was steadily declining, along with the land and the forage on the land.

As the basis of developing a practical plan for better use of the area, surveys were made to determine the character and distribution of the soils, the nature and distribution of erosion conditions and potentialities, the present and potential carrying capacity of the range and favorable locations for water development.

With this information, a systematic grazing plan was worked out for the entire area and put into effect. It consisted of the establishment of two grazing routes for 2,000 sheep each, and the timing and regulation of grazing over these routes. Forty-one water holes were established over the tract, and bedgrounds located so that each would be used not more than five consecutive nights on the average. In favorable situations some water-spreading structures were installed, and the area was fenced against trespass stock.

In spite of the increased number of animals using the area, range forage has increased 25 per cent. in carrying capacity, and numerous eroded areas are revegetating in a most encouraging way. The indications are that from time to time additional sheep can now be turned on this tract without unduly checking the improvement in forage.

The results obtained here, moreover, fit nicely into a larger project covering more than a million acres of range and irrigation land in the Wind River Basin. Some portions of this larger area have such little vegetation left that recuperation will be impossible without a reduction in the number of animals using the land. But the Riverton tract, together with other managed areas on which the forage is improving steadily, will relieve the pressure on neighboring lands by taking care of part of the animals now overtaxing them. Still other relief will be derived from the production of supplemental feed by a more conservative and effective use of available irrigation water.

Within the broader pattern of improved land-use for the entire area, still other adjustments in present use have been planned and to a large extent installed. Grazing, for example, has been excluded from certain critical areas from which flash runoff has resulted in serious flood damage to irrigated lands downstream. This control of upland grazing, together with the installation of small retention reservoirs, contouring and water-spreading structures, apparently has resulted already in the material diminution of flood flows.

Also, it should be noted, the project was developed only after a careful study of the economic situation of the land users, both irrigation and livestock operators, to determine how far land-use changes might be carried without overtaxing the economy of the individual rancher or irrigation farmer. These studies have considered the interrelation of the ranch and farm enterprise and indicate, for example, the opportunity for increased production and use of soil-conserving feed crops and the effect of such increases on the total production of sheep by the whole land-use enterprise.

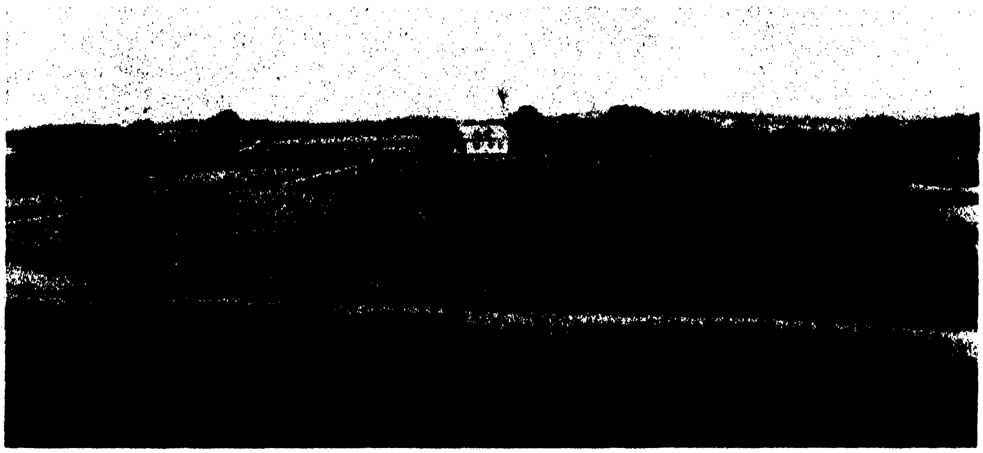
Equally fundamental adjustments in physical land-use practice have also been brought about in farming sections of the humid region through cooperative action by the Soil Conservation Service and farmers. Typical of such realignments are those accomplished in the demonstration project at Lindale, in northeast Texas. This project, it should be pointed out, is representative of the practical possibilities of effecting needed land-use adjustments in a large problem area embracing some 48 million acres: The Interior West-Gulf Coastal Plain in southern Arkansas, northwestern Louisiana and northeastern Texas. This problem area includes much submarginal land, a considerable part of which, although subject to serious erosion under present farming practice, is under cultivation. Approximately 60 per cent. of the land has slopes ranging from 2 to 8 per cent., and is subject to moderate to severe erosion; while about one tenth of the area exceeds 8 per cent. in declivity—a slope generally too steep for cultivation because of susceptibility to very severe soil washing. Thirty-five per cent. of the region is in cultivation, 45 per cent. is forested, 13 per cent. consists of pasture, and 7 per cent. is idle.

ROADS NEED EROSION CONTROL

ESPECIALLY THE UNIMPROVED COUNTRY ROADS ADJACENT TO FARM LAND. THIS ROADSIDE GULLY MAY EAT INTO THE ADJOINING FIELDS.

REFORESTATION IN MISSISSIPPI

OF ERODING FIELDS THAT WERE FORMERLY IN CROPS IS HELPING TO RESTORE THE USEFULNESS OF THE LAND AND PROTECT IT FOR FUTURE GENERATIONS.



ONE OF THE ORIGINAL TERRACED FARMS

EACH FIELD IS IMPORTANT IN SOIL CONSERVATION, FOR THE FIELD IS THE STARTING POINT IN ALL EROSION CONTROL WORK, BE IT FARM, AREA, STATE, REGION OR THE NATION.

In cooperation with land operators in the 23,000-acre watershed comprising the Lindale demonstration project, 80 farms were surveyed to determine the extent and distribution of individual soil types, erosion types and potentialities and the slope classes; as well as to show the location of farm, field and pasture boundaries, fences, drainage ways and other cultural features. With this information, readjustment and conservation plans were worked out individually for each farm, indicating not only the specific needs of each parcel of land, field, pasture, woodlot and idle area, but the measures necessary to effect required readjustments and conservation. The program for each farm was adjusted as nearly as possible to the income requirements of the operator. Careful consideration was given to prospective yields under the rearranged farm system, to the problem of utilizing the products grown under the reorganized plan and to the opportunities for developing supplementary income from properly managed woodlands and game resources.

Some of the major results thus far effected in the project have been: Control of erosion to a degree of effectiveness estimated at 85 to 90 per cent.; reduction of runoff by 25 per cent.; retirement of 33 per cent. of the original cultivated area to the permanent protection of grass, trees or shrubs; reduction of 46 per cent. in the area devoted to soil-impoverishing crops, with an approximately corresponding increase in the acreage of soil-conserving crops; increase of 100 per cent. in the pasture area; improvement of all pastures by contouring, reseeding and other measures; control of all gullies; improvement of all woodlands by thinning, planting and selective cutting; and treatment of all idle land for erosion control.

When the project began 52 per cent. of the area was under cultivation; 21 per cent. was in pasture; 25 per cent. in timber; and 2 per cent. idle. Under the readjustments made thus far, the corresponding percentages of use are: 35 per cent. under cultivation; 41 per cent. in pasture; and 22.4 per cent. in timber. Because of the trend toward livestock development in the area, eroded upland

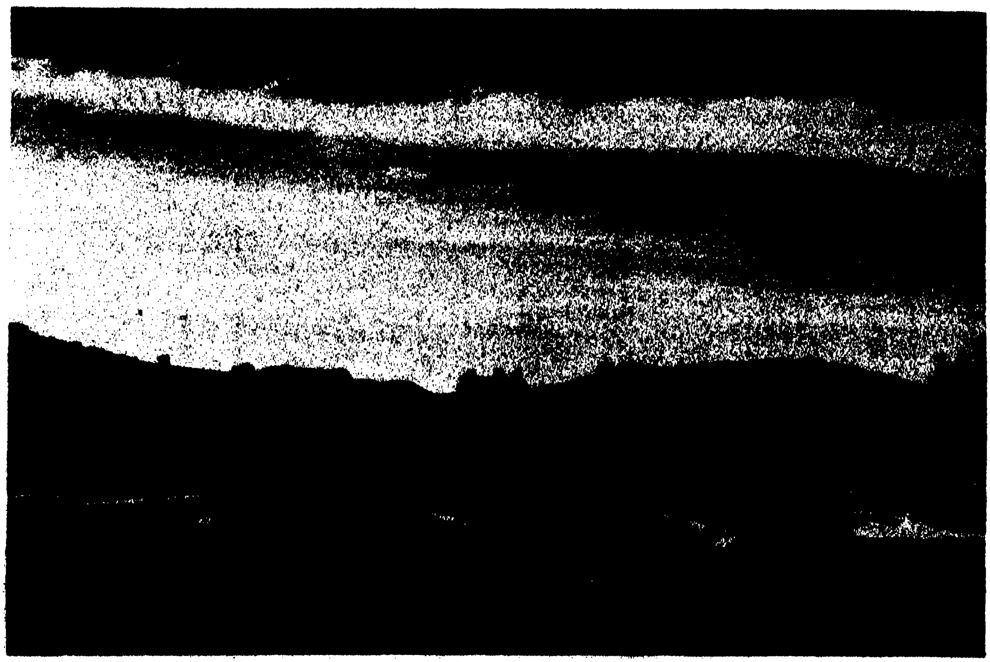
was for the most part retired to pasture instead of timber. Other areas of eroding upland were retired to a permanent cover of grass, and a comparably productive area of timbered bottom land was brought into cultivation in order that production volume could be maintained. This accounts for the slight reduction in the area devoted to trees.

These changes in land use on the farms participating in the Lindale demonstration project have not only produced definite results in conserving soil and moisture. They have brought tangible benefit in the way of increased financial return on the farm enterprise. A recent survey in the Lindale area showed average annual farm income for the three years 1935 to 1937, inclusive, to be $203 greater on cooperating farms than on those not taking part in the soil conservation program. The cooperating farms had an average annual income of $488 for those years as compared with $285 for the non-cooperating farms. For the two years before the project was started, average annual farm income for all farms in the watershed was $199.

Such local land-use changes as those made in the Riverton range area of Wyoming and at Lindale in the farming section of East Texas must be fitted, of course, into the larger picture of regional adjustment. They are, as a matter of fact, the individual pieces out of which regional and national land-use patterns must be designed.

Rapidly, now, those larger patterns are taking shape. In the semi-arid Southern Great Plains, for example, both the nature and the extent of physical land-use needs have been determined by careful surveys covering nearly 100 million acres.

On the basis of these surveys, proper physical use of the land over this large segment of the Southern Plains will mean an increase of 10 per cent. in the aggregate area devoted to grazing, an increase of 20.7 per cent. in the area devoted to farm pasture and an increase of 22.6 per



CONTOUR CULTIVATION AND CONTOUR DITCHING
PROTECT A VALUABLE PIECE OF LAND IN SOUTHERN CALIFORNIA.

cent. in the acreage of feed crops. These increases will call for a decrease of 30.3 per cent. in the acreage in wheat, 16.6 per cent. of the acreage in cotton, 12.9 per cent. in the acreage of miscellaneous cash crops and 8.1 per cent. in the acreage of corn. These readjustments reflect the need for a general shift from a hazardous cash crop agriculture to a more certain grain and livestock type of farming in the Southern Plains. To make this shift toward a stable agriculture in the Plains, the total area devoted to grazing and farm pasturage must be increased from 57,899,000 acres to 64,399,000 acres, and the total area of cash crops must be decreased from 28,823,000 acres to 21,576,000 acres. The area in feed crops also must be increased from 3,298,000 to 4,045,000 acres.

Extensive alterations of this kind over entire regions call for action along lines broader than the purely physical, of course. The same is equally true of the more local readjustments which together will make up the changed pattern of the region. The correction of physical land ills depends to a very large extent upon the economic and social factors which exercise such a tremendous influence on the way men use the land. The price of farm products may determine whether a man is able or willing to use his land well or badly. Rural roads are a most important factor in determining the feasibility of using land for one purpose as opposed to another. The tenancy situation in any locality has a marked effect on the use of the land, since tenants often lack a true incentive to use the land as it should be used. Complicating factors of this kind could be listed almost indefinitely to indicate the diversity of forces which must be dealt with if better land use in this country is to be a fact.

Nor is the ultimate effect of alterations in land-use practice limited to the physical betterment of the land. It is conceivable, for example, that extensive reorganization of our national land-use pattern will bring about a more even distribution of cash crops and a more regular volume of production, with consequent good effect upon surpluses and farm prices. It has already been demonstrated that through the establishment of good land-use systems on tenant farms it is possible to bring about a higher degree of satisfaction on the part of both tenant and owner and a greater inclination toward long-term leases on both sides.

To cite an interesting illustration in this general connection: In certain localities the filling of stream channels with the products of erosion has caused the formation of marshes and stagnant pools of water along the streams. As a result, malaria has become a menace to the population, where formerly the disease was unknown. Mosquito control by draining the marshes would be only a temporary palliative if erosion were permitted to continue over the uplands. The readjustment of land-use practices to prevent soil erosion on the uplands shedding water into these streams is consequently essential to the public health.

Important also is the effect of land-use changes in one section on conditions in other sections, adjoining or distant. Necessary readjustments in the physical pattern of land use may sometimes call for the removal of people from one section to another. This process, however, can not go beyond the productive capacity of the land available for the transfer of these people. Displacement of the population by retiring the whole of a large area of erodible land from cultivation, for example, will make it necessary to raise the level of productivity in some other area if the displaced people are not to suffer economic and social hardships. On the other hand, if the erodible area should be continued in production without increasing the productive capacity of the non-erodible area, the same kind of economic difficulty would arise with the

LAND RUINED IN ILLINOIS

IS PART OF THE 282 MILLION ACRES IN THE COUNTRY RUINED OR SERIOUSLY IMPOVERISHED BY EROSION. ANOTHER 775 MILLION ACRES HAVE LOST FROM ONE FOURTH TO THREE FOURTHS OF THEIR FERTILE TOP SOIL.

ruin of the former area for agricultural use. The remedy in such situation is to find an economically productive use for the land retired from cultivation, such as the development of a salable wildlife resource or the establishment of a productive orchard on a soil-conserving basis. This, of course, assumes that immediate absorption of displaced farm people into industry or other fields of livelihood will not be very great and that most of them will be forced to continue in agriculture. Possible difficulties of this kind indicate the importance of the relationship of land-use adjustment on one tract of land to the physical welfare of some other tract of land, as well as to the economic and social welfare of those who live on the land or are dependent on its produce.

Ramifications of the land problem thus could be explored almost endlessly. It will be sufficient merely to suggest that they extend into the fields of physics and chemistry, economics and sociology, health and sanitation, education, engineering, and into other fields as well. Obviously, there is no panacea. Whatever is accomplished will be brought about only by coordinating the progress of many programs in many fields toward a common objective.

And while to-day the emphasis is on action by public agencies to assist the actual users of the land, the need for effort along other lines is no less acute. There is need for a thorough understanding of modern techniques on the part of agricultural workers everywhere. We have developed a new kind of land survey, for example—a survey that is actually an inventory of the physical characteristics and condition of the land. It shows the dominant conditions of slope, soil and erosion, as well as the use being made of the land—factors we must know in order to determine the kind of treatment each parcel of land requires if it is to remain permanently in beneficial use.

These new surveys are of great significance to-day, when the matter of land use has come so importantly to the foreground of agricultural action. They constitute the very basis upon which any sound readjustment of land use for the conservation of physical resources and the betterment of human welfare must be made. Agricultural workers everywhere, I hope, will acquaint themselves with the principles used in making these surveys, and will equip themselves to interpret and put to practical use the knowledge made available.

There is need also for research into many of the complex aspects of the problem; into the economics and the sociology of land reform as well as the purely physical problems of readjustment. Likewise, there is need for continuing educational effort so that the gains made by action and research will not be lost as time goes on. People must be taught to think as a matter of course in terms of good land use if what we accomplish now is to be permanently effective.

Summarizing, it would appear that the essential elements of an effective public program of land use are: (1) action to assist people in readjusting physical patterns of use to the physical limitations of the land; (2) action to assist in correcting or mitigating the economic and social forces which tend to impel or encourage physical land abuse; (3) research to implement action with knowledge, and (4) education to establish basic principles of land use firmly in the public mind.

Unless the United States goes ahead vigorously, persistently and speedily to conserve the soil and to make far-reaching adjustments in our complex land economy, national decadence lies ahead. We must continue to capitalize upon experience and to advance through research. From the standpoint of our soil resource alone the need for action is now clear enough. Failure to act has caused the essential ruin of some 280 million acres of farm and grazing land and the injury of 775 million acres more. The average citizen does not yet fully understand the deep significance of this waste, nor realize the hardships it has caused in lowering tens of thousands of land users virtually to the level of pauperized farming with its attendant discouragement and inertia. Nor have we yet fully probed the social and economic implications of this single facet of the problem.

There is no longer a question of the need for coping with these evils. There is no longer a question as to whether we can cope with them. We know that we can. Millions of acres already have been anchored against erosion; new and practical conservation measures are being developed through research and experience on the land; many of our economic and social difficulties are being solved. We are moving constantly ahead, though not yet with sufficient speed.

It should be remembered that to-day's necessity for public action is the outgrowth of yesterday's failure to look more carefully to our land. Hindsight is easy; but foresight during the last century, when our present land-use picture was in the making, would have produced a different result. To-day we are simply retracing our steps across this land in an effort to correct past mistakes in the interest of the future.

EMILE JAVAL—FRENCH SAVANT

CENTENARY, MAY 5, 1939

By Dr. JAMES E. LEBENSOHN
DEPARTMENT OF OPHTHALMOLOGY, NORTHWESTERN UNIVERSITY MEDICAL SCHOOL

JAVAL, whose ideal was Benjamin Franklin, was himself of the Franklin type, and emulated his hero in consistent industry and manifold interests. For Javal was not only an oculist, but a legislator, journalist, educational leader, hygienist and social reformer as well.

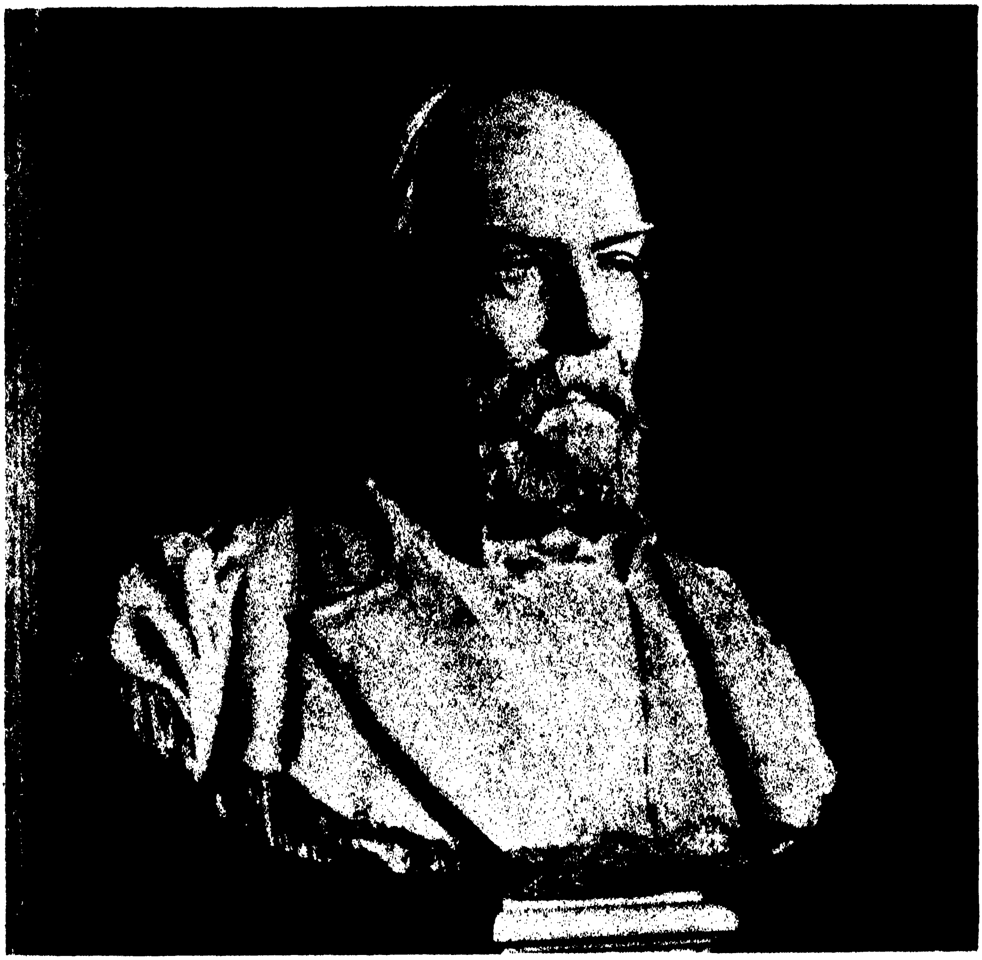
Javal's grandfather, Jacques, was a poor self-educated Alsatian, who peddled for a livelihood from the age of ten, but finally achieved enough means to found a small but successful bank. When this ancestor was born in 1780, four fifths of the 50,000 Jews of France were living in Alsace-Lorraine, having a communal government of their own, but very limited civil rights. Political emancipation first came with the French Revolution and its Declaration of the Rights of Man. In 1806, at the suggestion of Napoleon, the Jews of France changed their oriental patronymics to the type of surname used by the rest of French citizenry. Javal's grandfather inscribed his name Jacob on the register, which, miscopied by the clerk as Javal, became the family name thereafter.

Leopold, Javal's father, finished a careful education by a year in England, where he assimilated English mercantile methods and a love of liberalism. On his return, he joined an expeditionary force to Algiers, where his heroism was awarded the Legion of Honor. Back in mufti, his flair for vast enterprise extended beyond banking to politics, industry, commerce, mines, railroads and agriculture. An associate of the celebrated financier, Jacques Laffitte, and for fifteen years deputy, he maintained a leading position in the world of affairs.

In 1838 Leopold married Augusta de Loemel, the cultivated daughter of a leading banker in Prague. The love for Rousseau that Byron had awakened in the intellectual world was ardently shared by her and her family. Imbued with the idea of progressive education expounded in Rousseau's "Emile," her first child was named after the book and reared by its tenets.

Emile Javal derived from his father the spirit of enterprise, from his mother a devotion to service, from both a keen intellect. Not for him the gay life of a rich man's son; his way was rather that of the practical idealist, zealous in work and simple in tastes. Javal inclined to a scientific career and could not be persuaded to follow his father's footsteps. He originally preferred medicine, but, bowing to family opposition, compromised on mining, and after graduation accepted an engagement in the coal mines controlled by his family. His concern about his sister's squint and his discovery of his own astigmatism reawakened his interest in medicine. His first researches in optics received such encouragement that he abandoned mining and embarked on a medical career, in which he finally established himself as one of the world's foremost authorities on visual hygiene.

After the Franco-Prussian war, in which Javal served as medical officer, he became absorbed in civic issues, education and social reform. He followed his father's lead in politics, and for five years was deputy from his department. He opposed the French construction of the Panama Canal and prophesied disaster for the project. Fearful of depopu-



EMILE JAVAL

lation, he sponsored a law relieving families of seven from all direct taxes. Though the Javal law remained in force but a year, exemption privileges of similar pattern have lately been reconsidered. The influence of his studies on the factors affecting population is reflected also in the novels of Zola. An ardent advocate of adult education, he was with Camille Flammarion among the charter members of an association for the popular diffusion of scientific knowledge, and for many years its president.

Of independent means, Javal's office provided material for private study rather than a source of income. If a patient proved interesting, he would waive the fee and invite him to dinner. Once a month he visited the villages in his canton and gratuitously gave his services to the indigent—a tradition which his Danish assistant, Tscherning, generously continued. A vexatious lawsuit followed a report in which he deflated the advertised claims of some new lenses. An enlightened court fortunately decided for scientific freedom. His young sister, who is still living in Paris, has the distinction of being the first in the world to receive eye exercises in the treatment of squint. Javal's methods achieved a perfect cure, which has persisted to this day. Javal

discovered the eye movements in reading, which laid the basis of an objective analysis of reading ability that has since culminated in instruments for recording eye movements and for training deficient readers.

Javal proposed an original method for teaching reading and writing simultaneously. He emphasized hygienic school construction, proper posture and efficient writing habits. With many educators of that period, he favored vertical penmanship, a beautiful example of which is the hand of Thomas A. Edison. His studies of the effect of variations of light, paper and print on the ease and speed of reading foreshadowed the modern interest in the subject. Ever motivated by humanitarian ideals, he stressed that to facilitate reading and writing is to accelerate communication among men.

In 1897, the excitement of the Dreyfus trial, in which he was keenly interested, precipitated an attack of glaucoma that left him blind for some hours. Now keenly aware of his prospective doom, he prepared his notes for easy accessibility so that whatever happened he could carry on his appointed tasks. Three years later, stark blind, Javal resolved to imitate these brave souls like Euler, Huber, Milton and Fawcett, who had not been deterred by a like fate from magnificent achievement. He invented a writing rack to carry on his correspondence. To Javal, dependence was the chief misery of blindness, and, in a widely circulated book that he wrote at this time, he strove to help the blind to help themselves. He encouraged physical as well as intellectual activity, and himself, by means of a tandem bicycle, continued regularly his favorite exercise.

To his friend, Zamenhof, the oculist of Warsaw, who invented Esperanto, he made various acceptable suggestions to render the language even simpler. He pleaded for the general adoption of this auxiliary language, which would be advantageous to the blind, since it would permit an international use of Braille publications.

Death came on January 20, 1907. Throughout the civilized world scholarly journals and organizations paid homage to the passing of a personage. At the instance of his widow his famous library was transported to suitable quarters in the chief eye clinic of Paris, and a splendid bust by Verlet was presented to grace the reading room. On February 18, 1914, La Bibliotheque Javal was dedicated, a fitting memorial to one of the great scholars in medicine.

"WHENCE COMETH LIFE?'

By Professor WILLIS R. HUNT

LAFAYETTE COLLEGE

PHILOSOPHERS have for ages attempted to explain life and death and to determine where one leaves off and the other begins. Present-day scientists are continuing to investigate this burning question.

Maybe the turning point is where the protein-building catalyst or enzyme first appears. Although it is non-living itself, it no doubt is the precursor of life, that is, it precedes and gives intimation of the coming of life. Possibly the most primitive living unit may be the gene. Have any of you ever seen a gene? No! It can not be seen even by the ultra microscope, but if we are to account for the hereditary behavior of protoplasm we must postulate invisible genes. Genes, as you remember, are the units or atoms of heredity. Other assumptions are that the viruses or bacteriophages may be the most elementary predator or form of life.

It will not be possible to say just where or how life first appears, but some evidence can now be given that the genes and the viruses are at the boundary or border line of life.

Like life the origin of disease has been subject to many theories and much speculation down through the ages. Primitive peoples believed that evil spirits caused disease. In the Middle Ages invisible particles were thought to be the cause. Bacteria were not even seen until the middle of the seventeenth century, and were only proven to be the cause of disease about sixty years ago.

It has been estimated that there are seven hundred and forty-two living agents causing disease in man. Thirty-one are ascribed to a still unseen something, called a virus. There are some forty more viruses causing disease in the lower animals, fowls, insects, fishes and plants. Examples of some virus diseases, to mention a few, are smallpox, rabies, parrot fever, yellow fever, herpes, mumps, measles, infantile paralysis, warts, epidemic influenza and the common cold. Distemper of dogs, fowlpox, carppox, swinepox, jaundice of silkworms and the so-called mosaic diseases of the tobacco, potato and tomato plants are examples of virus diseases in other groups of organisms.

Just what the nature and properties of these "mysterious purveyors of disease" are has been one of medicine's and bacteriology's greatest problems. Up to recently the following three questions had not been answered: (1) Are viruses animate or inanimate? (2) Are they ultramicroscopic entities related to bacteria? (3) Do they represent inanimate chemical principles like catalysts or enzymes, for example, pepsin, an organic enzyme, which stimulates digestive changes in the stomach?

We may define a virus as an infective agent below the size limit of microscopic determination which passes through the finest made filters. They are obligate parasites; no saprophytic forms are known. This is not surprising, is it, since symptoms are the only means of recognizing them? They can not grow and multiply in artificial culture media, but in tissue culture, specific for the virus, the infective active agent has been developed. For immunization viruses are propagated by serial injection of animals. Their behavior is very much like that of a living organism.

An open mind is necessary in regard

to the nature of viruses. One of the smallest known viruses causes foot and mouth disease. It is only large enough to hold a few dozen protein molecules. Is this consistent with life? Would it be consistent if smaller viruses were discovered? Does not their minute size preclude their being alive? It must be remembered that no virus has a characteristic form or the ability to assimilate lifeless matter. Are not form and assimilation two of the chief attributes of life? These questions can not be answered, for we do not know whether there is a definite boundary line between the living and the non-living.

As a virus is dependent on living cells for its development, does not this suggest that they may be derivatives of those cells, an enzyme or catalyst, for example? Catalysts effect a chemical change. The viruses then may have the peculiar property of stimulating healthy normal cells to reproduce more virus substance. The living characteristics that are possessed by a virus are shown only when the virus is associated with living tissue, namely, metabolic assimilation of heterogeneous substances, adaptation and reproduction.

On the other hand, the principles of proof that a particular species of living organism is the cause of a specific disease is stated in Koch's postulates. First, the causal organism must be found in all cases of the disease; secondarily, it must be grown in successive pure cultures outside the body; thirdly, the cultures must be able to reproduce the disease in susceptible laboratory animals or plants, and lastly, the organism must be recovered from the artificially infected host in pure culture. No doubt if viruses were living they would follow these postulates. They do not satisfy number two, namely, cultivation outside the tissue of the host.

Most of the knowledge about viruses has been gained through the study of tobacco mosaic virus. It is the oldest known. It was first described in 1857, but its filterability was not discovered until 1892. It was then discovered that the extracted juice of a tobacco plant affected with mosaic would infect a healthy plant if pricked into its tissues or rubbed onto the leaf hairs, even after it had been filtered through a Chamberland filter.

Tobacco mosaic is the most infectious of all virus diseases. Even when dried and ground into a powder, diseased leaves will still have the property of infectability after months of desiccation. The virus may be extracted by ether, chloroform, carbon tetrachloride, toluene or acetone without any destruction of its infective properties. An infinitive amount of the virus will increase many times over when inoculated into a normal plant.

The symptoms of a diseased plant are the mottling of the leaves due to alternating patches or spots of light green or yellow, and dark green, but under certain conditions the mottling may be masked.

In 1921 a new concept of the nature of the tobacco mosaic was suggested. The substance of this concept was that it was a product of the host cell, a gene, perhaps, that has revolted from the shackles of coordination, and having the property of reproduction, continues to produce disease only in the living plant cells.

As tobacco mosaic virus is the most outstanding in having properties which are easily worked with, as stated above, and as it is typical and representative of all viruses it has been experimented with extensively. Countless numbers of tobacco plants have been grown and infected artificially. The diseased plants after a certain time were ground up, pressed and the tobacco juice containing the virus extracted. Protoplasm, in general, contains proteins, fats and carbohydrates. Certain enzymes are protein splitters or digesters. Proteolytic pepsin,

as noted before, is an organic protein digester. This enzyme was added to some of the plant juices in a test-tube and kept under suitable conditions to see if it would act on the virus. After a certain length of time a small amount of the solution was rubbed on the leaves of some healthy plants. No infection resulted after repeated tests, as the protein causing the disease had been digested. Pepsin is specific in its action; it will not act on fats, carbohydrates, hydrocarbons or salts. Therefore a sound conclusion that the virus is protein in nature can be made.

Certain chemicals such as ammonium sulfate or dilute alcohol will precipitate proteins. They were added to some of the diseased tobacco juice to which pepsin had not been added. A solid precipitate was thrown down. A bit of the supernatant fluid was rubbed on healthy leaves. No infection resulted. A different picture was represented when a neutral liquid, as water, was added to the precipitate and it was dissolved and then rubbed on normal leaves. Diseased plants resulted. These two experiments proved without doubt that the infective agent resided in the protein molecules.

To further prove the nature of the virus, the precipitate was again dissolved in a neutral liquid and ammonium sulfate compound was added. Crystals were formed from the solution. These crystals were refined by ten successive fractionations and recrystallizations. By this technique all impurities as well as all living matter was separated out. Why do we say that all living matter was eliminated? Because no protoplasm is known to possess the property of crystallization. Did you ever see a crystalline gonococcus, amoeba or a "crystalline chicken" either in a coop or walking down Fifth Avenue on Easter Sunday or any other day for that matter?

Now if these crystals infect healthy plants far-reaching results can be expected in regard to their nature. A few crystals were dissolved in a neutral liquid a hundred million or more times their bulk. Healthy leaves were again inoculated, and all the symptoms of the mosaic virus disease resulted. The conclusion of this experiment was that the crystals were made of many protein molecules, and each molecule of this cluster of crystals is a single virus of the tobacco mosaic disease.

Chemical analysis proves that the virus molecule is very large, a macro-molecule. Carbon, nitrogen, hydrogen and chlorine have been found in these molecules, but how many atoms of each and their arrangement is not known. That is, there is no chemical formula for a virus as yet.

In addition to the above chemical methods the ultracentrifuge clarifies the evidence as to the nature of these macromolecules. The ultracentrifuge gives us a knowledge of the protein itself, degree of purity and the extent of its concentration at each step in its isolation. A pure protein in true solution is made up of molecules of the same size and shape, and it will sediment at a constant rate in an intense uniform centrifugal field. The heavier the molecule the greater the rate of sedimentation. The sedimentary boundaries that arise between protein and solvent is determined by photographing. The molecular weight of the mosaic virus was found to be seventeen million times as heavy as a hydrogen atom. We may now think of this virus as a "macromolecule" with a structure that must consist of hundreds of thousands of atoms, and may be more.

Is this virus living or non-living? Remember that it can't be cultivated in a test-tube, but bacteria which seem to be their nearest living relatives can assimilate, grow and reproduce in this non-living medium. Yet the only way this virus can grow and reproduce itself is when it is stimulated by contact with the tobacco plant tissues. An infinitesi-

mal particle will infect a normal plant, and in a few days the whole tobacco crop will be diseased and producing the original amount of virus a million times over. Is not this ability to propagate itself a property of living things?

Maybe this virus lives a Dr. Jekyll and Mr. Hyde sort of life, a dual personality, alive in certain phases of its existence and raising havoc in a tobacco field, and under another set of conditions not alive and harmless as sterile water. It is alive and has the attributes of living things when in the presence of tobacco protoplasm and non-living in other environments.

This crystalline protein causing tobacco mosaic has many points in common with a gene. They are about the same size. They both reproduce under certain specific conditions and can refrain from reproducing for long periods of time without losing this property when favorable conditions exist. Quite a human characteristic! This characteristic can be illustrated by the inactiveness of the genes in an unfertilized egg of a human, thank goodness, or in the resting seed of a daisy or the inactiveness of a virus in dried tobacco leaves or in a spittoon.

Furthermore, the gene and the virus have another similarity in common, namely, that of unstability. A gene can and does mutate. The virus may suddenly change or mutate to a "masked" form showing no mottling, and this form in turn change into another strain showing a yellow mottling in place of the original light green. The size of the virus molecule increases with these mutations.

The gene to be effective must associate with other genes. It doesn't work alone. A virus must be in contact with living protoplasm to be effective. Is this single gene or virus molecule alive? The evidence points to the answer, "No."

Azotobacter is a heterotrophic genus of nitrogen-fixing bacteria which is able to use free uncombined nitrogen of the atmosphere. It grows in well-aerated arable soils; it is a strict aerobe. Azotobacter is about the size of a yeast plant cell. It obtains its energy from the oxidation of carbohydrates in the soil, and takes in free nitrogen from the air for the synthesis of protoplasm. Is not this a property of living organisms?

Some Russian chemists recently carried out a very interesting experiment. A culture of these bacteria were grown. They were then crushed and their juices filtered off. There were no traces of the cells present. To this filtrate a carbohydrate was added, oxygen and nitrogen gas were bubbled through the liquid. This filtrate then produced ammonia like the culture of living bacteria in the flask of nutrient broth. What was producing the same chemical reaction in the lifeless fluid that was carried out by the living bacteria in their metabolic activities? Enzymes were no doubt responsible in both chemical reactions. More ammonia was produced in the test-tube than in the living culture. May not this be explained by the fact that *in vitro* the enzymes were not shackled with the extra burden of producing the characteristics of life?

We are still at the starting line of life, and much more work will of necessity have to be done before we can answer all the questions in regard to the nature of genes and viruses. Can't we make the assumption that the organization of matter is just a step in the production of life? Isn't it a matter of complexity of organization from these simple bacteria through the protozoa and metazoa to ourselves? Doesn't matter itself start from protons, neutrons and electrons, combine to form atoms, and atoms to form molecules, and aggregates of molecules to form crystals?

Is not the phenomenon which we call life the chief difference between these organizations? Somewhere and somehow in the general mixup in the formation

of carbohydrates, fats and proteins from simpler substances, the catalyst or enzyme makes its appearance. The first catalysts may make amino acids, other catalysts simple proteins from these amines, and then other catalysts more complex proteins. The association of many proteins to form large molecules may be the first genes. These genes arranged themselves in strings to form chromosomes, specialization developed and the attributes of life were exhibited.

From the evidence which has been given there seem to be two possibilities as to where life first appears, either as macro-molecules in the form of genes or macro-molecules as viruses. Both genes and viruses fit in part into the Mechanistic and the Vitalistic theories of life. But whatever the first form of life was, we may well assume that the enzyme is the precursor of life, and whenever it finds itself in a favorable environment it becomes active and life begins.

EMINENT MEN

By Professor MAPHEUS SMITH
UNIVERSITY OF KANSAS

THE present review sums up in the briefest possible form what has already been thought and studied about eminent men as a class, and what we desire to know, and indicates the significant gaps in our knowledge. It is presented because of a belief that the understanding of historical events and the solution of social problems will be advanced as much by the positive approach (the study of leaders and eminent men) as by the negative (the study of criminals, the unemployed and the mentally deficient); and because of a desire that knowledge of eminent men and leadership will eventually be as full as our knowledge of criminals and crime. The treatment does not emphasize any point of view to the exclusion of others, except that it is a *generalized* treatment of an entire class rather than of specific individuals.

"Eminence" refers to superior position. The eminent man is one whose superior position rests upon a degree of recognition by other men rather than upon power. Genius and eminence are essentially different, although most men of genius are, or will be, eminent and many eminent men have exhibited genius. Every man of genius has very superior ability, especially in inventiveness and originality, while every eminent man has obtained a superior degree of formal social recognition. Different from each is the leader, who is the stimulus-giver in any situation resulting in the expressed integration of originally divergent tendencies of a number of people. For practical purposes, such as the present study, eminent persons are those who have obtained recognition in historical encyclopedias, or in lists of prominent contemporaries, or who have been awarded national or international prizes and honors for actual accomplishments. The study of eminent men is significant because eminent men are the *élite,* the social type of top-ranking men who are recognized as the most important of their times and of history, who have led in social change and in social organization and who serve as models for subsequent generations.

THE SOCIAL RÔLE OF THE EMINENT MAN

Because so little consideration has been given to the effect of the eminent man upon history, the significance of eminent men may be related to the individualistic or "great man" conception of history and

human society. Extreme theories of the social significance of great men are of two sorts: first, the great man is the essential mover in historical and social events; second, the great man is only one element in historical and social change. There are also numerous combinations of these views. The chief early conceptions of the great man as the essential mover in social events were the court historiographic, the clerico-ecclesiastical and bourgeois conceptions.[1] The causes of development of these conceptions are a combination of inadequate information and restricted personal and social background on the part of the theorist with the lack of ability to dissociate himself from his background. The chief emphases of the opposite theory are: the great man's ideas are chiefly borrowed, the great man's position in his time and in history is the result of circumstances over which he has no control, and the great man merely personifies a process over which he has no control. The first of the extreme views is too microscopic, the second too telescopic, each is too restrictive and uncritical, and only a combination view can be satisfactorily realistic. The problem really needs to be stated in another way: the important thing is the social rôle and not the individual. But the rôle is necessary, which is to say that individuals who do certain types of things (such as lead and originate) are necessary, but they are limited by social conditions which they can only partially control. Because both individuals and social conditions are necessary in any explanation of social fact it is impossible to say which is the more important of the two factors.

Most of what has been said about the great man applies to the eminent man. But all eminent men are not dynamic figures; all do not contribute to social change. Many are merely figureheads. Eminence is often but not always the result of recognition for dynamic contributions. It provides opportunities for such contributions but does not insure them.

[1] F. Oppenheimer, "History and Sociology," Chapter xix in W. F. Ogburn and A. Goldenweiser (editors), "The Social Sciences and Their Interrelations," Boston, 1927, p. 221.

Climatic and Physiographic Factors in Eminence

A review of the relationship of climate to the place of birth of prominent persons in all the European nations, in China and in the United States and of the relationship of climate to the distribution of patentees of inventions over the world shows that there is only a loose association between climate and production and place of residence of ascendant persons. The same is true of the relationship of air pressure, topography, soil and volcanic character of the land to the birthplace of prominent persons. Likewise, temperature and other meteorological variations are only very loosely associated with invention and other forms of creative activity. The most satisfactory conclusion at present is that geographic and climatic factors are only indirect in their influence and set only the most extensive limits of variation, within which other factors account for the distribution of place of birth and residence of prominent persons.

Anthropometry of Eminent Men

Examination of the scanty evidence available suggests the tentative conclusion that eminent men and leaders as a class possess a superior degree of height and weight; superior weight-height ratio; a superior degree of head size, cranial capacity and brain weight; superior size of cerebral areas in ratio to body weight, deeply set eyes, orgnathism, large nose and deep and powerful voice. The evidence on the relationship between social recognition and each of the following characteristics is not consistent enough for even tentative conclusions: cephalic index, distance between eyes, size of eyes, lines of lips, thickness of lips, anomalies in facial and cranial contours and pigmentation. "Handsomeness of appear-

ance" had not been investigated enough to be included in the summary. The items of the former group may be of some significance either by adding to the physical or mental powers of the ascendant individual or by adding to his impressiveness over those who follow him or give him social recognition. However, there is no perfect assurance that these characteristics contribute anything to the eminent man. It is possible that they are merely associated with a superior type and are indices of all-round superiority without adding anything important. The correct answer to this question is unknown, but the total importance of all the anthropometric characteristics appears not to be very great.

Fundamental Biological Factors

Because leadership and achievement always involve activity on the part of the leader and achiever, some factor accounting for the excess of activity must be associated with leadership, achievement and eminence. Since there are prominent physical aspects of all activity, superior energy, endurance, strength, health and other positive or dynamic factors are associated with leadership, while disease or inferior energy, endurance, strength and health are rarely associated with personal ascendancy. On the rare occasions when "negative" biological conditions are associated with leadership or achievement, the achievement is intellectual or mental rather than physical, because mental activities make relatively little drain on physical resources. Studies in biochemistry have shed considerable light on the dynamic agents in the living organism which undoubtedly underlie all explanations of action; but little relationship has been discovered between biochemical facts and leadership. Even should important relationships be discovered, the biochemical facts would operate only through actions that must be described in other than biochemical terms if leadership and achievement are to be accounted for.

General Intellectual Status

There is evidence from a number of sources that leaders have superior intelligence and that as a class they surpass followers as a class. It is also true that intelligence is commonly considered to be an attribute of all sorts of leaders. The average intelligence of eminent men in childhood is far above that of the general population, and this is especially true of philosophers, writers, revolutionary statesmen and scientists. However, degree of eminence is very slightly related to estimated intelligence, and intellectual status is not a satisfactory basis for the prediction of leadership, achievement or eminence. General intelligence is a characteristic which is a powerful aid to leadership, achievement and eminence, if other conditions are satisfactory.

Special Abilities

The existence of special musical, graphic, calculating and mechanical abilities which are not learned and which are not always associated with general intelligence is now beyond question. At least a superior degree of musical and graphic talent is necessary for success in music and the graphic arts, and most if not all of the most eminent persons in these fields have possessed a high degree of the talents. The other special abilities are not so clearly related to eminence. Speed of action is not a true special talent, but it is not entirely learned. It is very likely a factor in initiative and therefore is especially significant for leadership, and to some extent for all social ascendancy arising from unformalized and uninstitutionalized social situations.

Originality

Originality in its broadest sense is the ability to bring into existence some idea or material construct that never before

existed in the same form. Two types can be distinguished, individual and social, the former being common, the latter very rare. Social originality is much more common in the man of genius than in the average of talented persons, and individual originality of the man of genius may also surpass that of other men. But there are no known differences between the process of originating in the men of genius and in others. There are two methods of accounting for original actions—reasoning to new combinations of elements and intuition. Each of these can be explained in neuro-psychological terms as the development of action along neural paths, and the translation of this action into consciousness which is a necessary step before the action can be communicated to others. It is argued that some nervous and symbolic systems are more complex, sensitive and unstable than others, and that people possessing such organisms are likely to be men of genius. Originality is partly associated with general intelligence and with memory, but is quite different from each. Originality is a prerequisite of leadership and eminence in all artistic fields and is necessary in almost all intellectual fields. In practical life and in executive leadership it is not so important, but a limited degree of it is an advantage.

Negative Psychological Factors

Under this heading are included the relationships of mental deficiency, mental diseases, epilepsy and psychopathic personality (considered generally to be handicapping or "negative" psychological conditions) to leadership and eminence. Except in very restricted situations, mental deficiency is certainly a handicap. On the other hand, definite mental disease is not uncommon among men of outstanding genius, and it may even be of importance in increasing prestige, but psychosis very rarely is known to contribute anything to achievement. Epilepsy also is not unknown in the eminent, but it is of small significance in accounting for achievement or recognition. Psychopathic personality, which is a very indefinite conception, is often claimed to be associated with originality and with eminence. Psychopathic behavior does not seem to be closely associated with leadership, but rather with originality and through that with prestige and even eminence. But until the term "psychopathic personality" is more carefully defined, its use is extremely likely to lead to circular reasoning.

Personal Behavior Traits

The social behavior characteristics most definitely associated with eminence are trustworthiness, conscientiousness, desire to excel, desire to dominate, self-confidence, self-esteem, quickness of apprehension, profoundness of apprehension, originality, extent of mental activity, forcefulness, capacity to work with distant objects in view, strength of will or perseverance. Extreme depression, liability to anger, unconventionality and desire for admiration are not uncommonly associated with eminence. There are some variations in the traits from one field of eminence to another, and considerable variation between traits associated with leadership and those associated with eminence. The traits of most importance for all types of personal ascendancy are enthusiasm, self-control, knowledge, originality, dependability and consistency, morality, sincerity, industry, devotion to an external cause, perseverance, depth of understanding of social behavior, singleness of purpose, foresight, flexibility and versatility, tact, sense of humor, speed of action, initiative, decisiveness, friendliness and sympathy, aloofness, self-confidence, confidence in others, skill and ambition. However, the most important thing about the social behavior traits of the leader and eminent men is that they always relate to some specific situation,

and in that situation relative superiority to the follower and the masses is the universal trait.

Age Factors in Leadership and Eminence

Age is positively associated with leadership and influence in all periods of human life, except in extreme old age. Leaders have a somewhat greater average age than their followers, even where the activity is limited to a relatively small age range. The means of personal influence also undergo changes from infancy to adulthood. Some achievements of outstanding men of genius are often made very early and most men of genius continue to make achievements until advanced in age. There are striking variations from one field to another. Recognition lags behind achievement, but never so far that many men first become eminent at an advanced age. The necessity of achievement and the passage of time between achievement and recognition go far to account for the greater average age and longevity of eminent men as a class.

Developmental Aspects of Personal Ascendancy

In childhood and youth persons who are to become eminent exhibit many physical, mental and social characteristics similar to those of eminent persons, and in most cases the man clearly is foreshadowed in the child and youth. Children who combine precocity and well-rounded superiority tend to develop into leaders and later into socially prominent persons. Irregular development is more rarely associated with leadership than is consistent precocity, while consistent retardation is opposed to individual ascendancy and is conducive to consistent followership. Men of genius often exhibit "childlike" traits, but these are generally one aspect of unconventionality, which in intellectual and artistic fields is often recognized as originality. The tendency to be a leader shows stages of development as clearly as do other aspects of the individual's history.

Sex and Eminence

Far fewer women than men attain social prominence. This is especially true in law, business, science, religion, public office, journalism and medicine, but even in the field of education their standing is little better. In acting and dancing women equal or surpass men; and in authorship and social welfare they compare favorably with men. One widely accepted explanation is sex-linked variability in the male, but this is not apparent at birth, and in childhood and youth these factors are not of very great significance. In youth sex differences are more pronounced and there may be a tendency for the intelligence of the female sex to decline as age increases. There is, however, no evidence that the decline is sufficient to account for the ultimate sex differences in the production of eminent persons. Aside from a possible sex-linkage with decline in intelligence, there are several biological differences that affect social recognition, such as less physical strength, smaller size, less endurance, less impressive voice and handicaps accompanying the function of reproduction. Other factors that may prove to rest on hereditary foundations are the non-competitiveness and lack of dynamic impulse of girls and greater emotional instability. However, social pressure combined with difference in social rôle can easily account for most of the difference in eminence, and these factors even may account for some of the so-called inherited differences, such as aggressiveness in the male.

Race and Eminence

Each of the main races of mankind has made some contribution to the groups of world-historical eminent persons and contemporary notable persons. There is no absolute race difference in inventive-

ness, but there are striking differences in relative contribution. The white race stands supreme, the yellow race second, the black race third. The American Indian has contributed but few persons of prominence. Pure-blood Negroes have much less chance of obtaining formal social recognition than mulattoes. Some of the difference may be due to biological factors, but the precise amount is still unknown, since certain social conditions confuse the issue. While not a strictly racial group, the Jews have been mentioned as the most superior group of mankind, especially in intellectual, commercial, artistic and scientific pursuits. The same is true of the Anglo-Saxons, also very superior, as were the ancient Greeks. But in the case of these groups there is no unquestioned evidence that the cause of superiority is racial and not social.

Civilization and Eminence

The culture of modern Europe and its colonies has produced far more of the eminent persons of history than any other of the great cultures. The Graeco-Roman culture ranks second, and all others lag far behind. The ethnocentrism of history-writing, which can not be wholly escaped, is the dominant factor accounting for the rank of the culture in this particular.

National Origins of Eminent Men

Without regard to population, the most favorable world-historical loci of world-historical eminent persons, according to the point of view of the present historical period, which is the only age of modern significance, have been, in order, the British Isles, France, Germany, Italy, Ancient Rome, Ancient Greece, the United States, Spain, the Netherlands, Sweden, Russia, Denmark and Switzerland. The order varies in several fields of eminence. Information is available only with regard to European countries from 1600 to the present time when the population of the various countries is taken into consideration. In this item Scotland and England lead, followed in order by Iceland, Denmark, the Netherlands, France, Switzerland, Ireland and Germany. Northern and western European countries have advantages over southern and eastern countries and small ones over large ones. The rank positions of all countries are, however, very imperfectly known because of the limited study on this question and the peculiar difficulties of historical research on population groups.

For contemporary prominent persons the most favorable locus, as determined by number of prominent residents per unit of population, is Denmark, followed in order by Norway, Sweden, Switzerland, the British Isles, Finland, the Netherlands, Hungary, Austria, France and Belgium, Germany and the United States and Canada. When only persons of greatest eminence, winners of Nobel Prize awards from 1900 to 1937, are included, the order changes to the following: Switzerland, Denmark, Norway, Sweden, Austria, the Netherlands, Germany, Belgium, the British Isles, France, the United States and Canada, Hungary and Italy. The advantage of the northern and western and of the smaller countries is again obvious.

Regional Origins of Eminent Men

Every country has its more and less favorable regions of birth and residence of eminent men. These have been studied in detail for France, Italy, Germany, the British Isles, China and the United States. The distribution in the United States is most closely correlated with relatively cool and dry climate, a population possessing a relatively small proportion of people inferior either biologically or socially, a high average intelligence test performance, a relatively large proportion of persons of

superior intellectual status, superior health and health facilities, and a large urban population. To these items may be added large per capita income; relatively large ratio of per capita savings bank deposits to per capita income; superior economic efficiency; superior rank in consensus of wealth; large state government expenditures for education, hospitals, roads, etc.; superior condition of the state school system; large per capita circulation of both widely read and "highbrow" magazines; small proportion of Methodists and Baptists in church membership; small ratio between population and number of prisoners committed to federal prisons and to the state prisons of New York and California; general condition of superior education and culture; general condition of superior public order; general condition of superior morality and respect for fundamental law; and general condition of superiority in wealth, education and general culture, health, public order and respect for fundamental law and morality. Limited evidence suggests that the United States is not unique in the association of eminence with these conditions.

Rural and Urban Distribution

Urban areas are more favorable as places of birth and rearing and far more favorable as places of education and residence of prominent persons than are rural areas. Only agricultural leaders and master farmers surpass the general population in percentage born and reared in rural areas, and only master farmers surpass the general population in proportion residing in rural areas. Women agricultural leaders surpass the general population in percentage born in urban areas. When the crude differentiation into rural and urban areas is analyzed further the most favorable place of birth for eminence proves to be suburbs of large cities, followed in order by villages and small cities, cities of medium size, large cities and farms. Large cities are outstanding as places of residence of the prominent, followed in order by smallest urban communities, medium sized cities and rural areas. It also appears that small state university cities outstrip all others as favorable places of birth and residence for social prominence, followed in turn by capital cities of states, large metropolitan centers and metropolitan manufacturing centers. The explanation lies in environmental factors, such as the handicaps of rural residence, farm occupations and low economic status; the greater access of urban dwellers to the determiners of prominence; and the fact that the urban point of view dominates in determining what is socially important.

Social Position and Eminence

The economic status of eminent persons is certainly much higher than that of the general population and is one of the most clearcut correlates of eminence known. The association is both due to the fact that high economic status carries prestige and power and also to the fact that acquisition of social influence tends to be followed by opportunities for economic improvement.

The occupational status of contemporary and historical eminent persons as a class is very superior. The occupational and industrial groups providing the greatest opportunities for contemporary prominence are, in order, literature, college and university teaching, painting and sculpture, the other professions, architecture, acting, music, business, manufacturing and agriculture. Chances for eminence of persons in these occupations correspond closely with the social prestige of the occupations. The occupations of the parents of prominent persons are also superior. As a consequence, occupational transmission is somewhat greater for prominent persons than for the general population.

Mobility and Stability of the Eminent Person

Ecological or spatial mobility of a person is a handicap to eminence unless the person is moving toward a more favorable opportunity for eminence; and psychological mobility is always a handicap to leadership and eminence, at least temporarily preventing leadership and recognition and destroying that which already exists. Movement upward in social status is an aid to total influence if it is a movement toward greater opportunities for eminence, but again mobility, which breaks more psychological ties than it makes, is always a handicap to leadership and eminence. The importance of maintaining psychological ties is shown by the relatively few changes in occupation of the most outstanding persons. Rise to a position of eminence requires considerable time, and frequent changes of occupation usually reduce the chance of rising. However, mobility is of advantage to those whose influence it does not reduce, since it gives them broader knowledge and insight. The person in intellectual and artistic pursuits is especially likely to gain by travel and new experience.

Home and Family Factors

The marital status of the eminent man is not greatly different from that of the professional classes, but a much larger proportion of eminent women are single than is true of the total population. The most illustrious men are similar in this respect to prominent women. The average age at marriage of prominent men is considerably greater than that for the general population, the proportion of childless marriages is larger, and the average fecundity is smaller than that of the general population, but not widely different from that of the population of the same social class. The oldest child has more chance of being eminent than the child of any other order of birth. It is not entirely clear whether or not the youngest child has more chance for eminence than the intermediate children. The parents are older at the time of birth of the child who becomes an eminent person than is true of the parents of an average child. There is a positive relationship between age of parents at the child's birth and degree of eminence. Home and family social relationship factors of especial significance are normally constituted homes; encouragement, stimulation and patient teaching by parents; harmonious marriage relationships; and harmonious relationships with children.

Association Factors in Eminence

A relative degree of both association and solitude are required by all persons, and the ascendant individual is no exception. But intellectual and artistic leaders require a greater proportion of solitude than do executive and other leader types. Associates of eminent men and leaders tend to be leaders and prominent people. The community leader's efforts are given to many organizations rather than to one or two, and the number of organizations with which he is associated tends to surpass the number for the average person.

Education and Eminence

The educational background of eminent persons is superior to that of other classes and always has been. Education is also becoming increasingly associated with eminence. The association is closer for professional fields and less close for the artistic and executive fields. The responses of eminent persons to scholastic training have also been superior to those of other classes. Technical education, however, is not clearly required for eminence, and indeed it has been claimed that education does not "cause" eminence or leadership, but that it selects people of high ability, and that people lead and attain eminence because of the high ability.

Religion and Eminence

The religious affiliations of eminent persons are incompletely known, but it seems clear that a larger proportion of the more selective religious groups are eminent men than is true of the other religious groups. Children of clergymen have a greater chance of eminence than children of any other large occupational group. However, the religious background is more selective of than it is contributive to, eminence and leadership, in this respect resembling the educational background.

Synthesis of Factors in Eminence—Hereditary and Environmental Factors

Most of the facts accounting for eminent men can be interpreted in terms of either hereditary or environmental factors, but the man at the time of achievement is so clearly a product of original stuff and of experience that only a theory based on organic interrelation of hereditary and environmental factors is justified.

Synthesis of Factors in Eminence—A Sociological Interpretation

The only completely satisfactory explanation of eminence must be complex, coordinated of the characteristics of the eminent man, of those people whose recognition makes him eminent and of the conditions surrounding both the eminent man and his electors. In addition, there must be added the dynamic element of interaction which may be called the process of election. The characteristics of the eminent man are those that have already been mentioned. Electors are of two sorts: first, experts and critics in every field of endeavor, and historians who cover all fields; and second, the masses. The evaluation of each class of electors is due to the influence of the eminent man's characteristics, of his achievement, of the general cultural conditions—including others who place a superior evaluation on the man and his accomplishments; and to special means of influencing others in his behalf, such as publicity, propaganda and the claque. The process of election is distinguished by a great deal of discussion and rationalization and has a definite developmental history. There is great variability in the total conditions accounting for each eminent person, and it is hopeless to expect this fact ever to change in a society based upon the present plastic individual organism and the social organization of the leading countries of the world.

The Future of Eminence

The social conditions that help to produce social recognition and eminence show no signs of waning. Also, the native ability of the race is neither appreciably increasing nor decreasing. So we may expect that eminent men of the same type as the present and past will continue to be produced as long as the individual has any social value. The mass point of view may replace the tendency to put a special value on the individual, but until the personal nature of human nature changes it is unlikely that men will cease formally to recognize superiority in their fellows.

BOOKS ON SCIENCE FOR LAYMEN

THIS EARTH OF OURS[1]

THIS book is almost all that its publisher claims for it. It is well written for its particular audience and is unusually well illustrated both by photographs and diagrams which are equally expository. I can not think of a better traveling companion for the non-professional man who has any interest at all in his environment and it even might intrigue a non-interested person into a cumulating interest.

It discusses in easily understandable language the origin of the earth and its early history; how scientists compute its age; the various kinds of rocks of which it is composed; volcanoes, geysers and springs; the formation of mountains and other natural wonders; as well as such topics as the origin of life and the panorama of life that has passed across the stage during the earth's long history.

It is written, it seems to me, with more of a feel for the physical than for the organic side of geology, but the latter topics are good as far as they go. There is one blemish, which is that it appears to have been written for a particular kind of layman, namely, the Catholic layman. While I do not take exception to any specific statement, I certainly am not in the least interested in the official position of the Catholic Church with respect to any biological or geological hypothesis, and think such statements have no place in a book with the avowed purpose of this book.

One need not consider publishers' blurbs too seriously, but when we are told the author's "whole life's work has been dedicated to geology" one expects a reasonable maturity, at least some loss of hair or wrinkled brow or whiskers, and it is somewhat disconcerting to find that the author is in his early forties.

EDWARD W. BERRY
THE JOHNS HOPKINS UNIVERSITY

[1] *This Earth of Ours.* By Victor T. Allen. Illustrated. xvii + 364 pp. $3.50. Bruce Publishing Company.

PLANTS AND ANIMALS OF THE DESERT[1]

POPULAR interest in natural features of the desert has grown rapidly as the southwestern states have become more and more accessible to motor travel. Agencies for guidance of the interest have been few. In an ample book entiled "Deserts" Gayle Pickwell has supplied an attractive guide to desert plant and animal life, popular in style and reliable in its facts. The essential geographical and biological features of deserts are briefly described and attention is drawn to the small desert-like areas which occur far outside the continental deserts. Much more could have been said about the physical conditions, and the author's previous book "Weather" is an assurance that he could have added a long and interesting chapter on the climatic features of desert.

The treatment of desert life is based almost entirely on the Colorado and Mojave Deserts of California. Southwestern Arizona is designated as a part of the Sonoran Desert. There are very few respects in which the areas on the two sides of the Colorado River differ, and the Colorado Desert is essentially a subdivision of the Sonoran Desert.

A few paragraphs are devoted to each of the outstanding plants and animals. The examples are well selected and the comment on them will answer just the questions that the inquiring mind is apt to raise. Many ardent devotees of the desert will find the discussions far too

[1] *Deserts.* By Gayle Pickwell. xvi + 174 pp. Octavo. $3.50. Whittlesey House, McGraw-Hill Book Company.

brief. The sumptuous illustrations are the commanding feature of the book and do as much as the text to describe land forms, animals and plants. The pictures of the reptiles are particularly fine. Those of the scorpion and centipede have been enlarged almost to the scale of the popular dread of them. Some of the plants have been enlarged more than is necessary for the best effect.

It is obvious that Professor Pickwell is a keen and patient observer. He knows the desert well, and betrays his admiration for the markings of the rattlesnake, the flowers of the desert lily and the ripples on the dunes. His statements of fact are authentic, without the exaggeration so common in popular books on natural history, and give the reader the impression that he knows a great deal more than he is telling—as an author should. The ocotillo (*Fouquieria*) is not the only member of its family, although it is the only one in the United States. Ocotillo does not mean "little pine" but "little torch," although the torch pine of Mexico is commonly called "ocote." There are few such mistakes. The book is a fine example of the better sort of natural history, and helps to mark the advance that a more exacting audience now demands.

FORREST SHREVE

THE STORY OF A CENTURY[1]

THIS encyclopedic work is the second volume of the author's History of Science, the first volume having covered under a similar title the sixteenth and seventeenth centuries. If the author carries out his evident intention to continue his work with a corresponding history of the nineteenth century, it will be interesting to find how many volumes will be required.

Before undertaking such a monumental work as the history of the science of the eighteenth century, an author must adopt some systematic approach to the task, for otherwise the reader would become lost in the endless details of, and interrelations among, scientific and technological advances. For fairly obvious reasons, Professor Wolf has not followed the chronological order of events. Instead, he discusses the different phases of his subject in the order of "diminishing generality (or abstraction), beginning with mathematics and ending with the biological sciences." Without contending that he has not chosen wisely, it may be noted that psychologists often point out that we normally proceed from the particular to the general and from the concrete to the abstract. If an author should discuss astronomy, "in the order of diminishing generality," he would start with a mathematical theory of the universe and end with descriptions of the planets and methods of observing them. To present the history of science during the eighteenth century is a formidable task. The science of this century had its roots in earlier periods; it developed with unparalleled diversity and speed; and it is to be interpreted in the light of nearly a century and a half of later developments.

In conformity with his general plan of beginning with the most general and abstract subjects, Professor Wolf treats in order mathematics, mechanics, astronomy, astronomical instruments, marine instruments, light, sound, heat, electricity, etc., through a total of thirty-two chapters, the last two of which are on philosophy. It will be at once evident that the arrangement is not without difficulties, for many men contributed to several of the fields into which Professor Wolf divided the history of science. For example, Gauss made last-

[1] *A History of Science, Technology and Philosophy in the Eighteenth Century.* By A. Wolf, Professor and Senator, University of London, and Head of the Department of History and Philosophy of Science. 345 Illustrations. 814 pp. $8.00. The Macmillan Company.

ing contributions to mathematics, mechanics, astronomy, astronomical instruments, magnetism and meteorology. Dr. Eric Bell refers to him as a scientific giant of his day. Yet Professor Wolf refers to Gauss only three times, and in each case almost incidentally. This scant reference to one of the greatest scientists of the century under discussion is mentioned to illustrate the fact that no man covering so many vast fields can treat each of them with the perspective of a specialist in it. That defect, if it is a defect, is inevitable in all such ambitious undertakings. On the other hand, the writer on so many subjects treats all except those in which he may be a specialist with the enthusiasm and freshness of the amateur. These desirable qualities may more than offset for the general reader any minor errors as to facts or differences in point of view from specialists.

The history by Professor Wolf will undoubtedly be a valuable reference book. Although it is necessarily filled with many names and with references to a multitude of advances in science during a period of its rapid unfolding, it is systematically arranged, clearly written and generously annotated. The reader can get from it a clear idea of the advances in any field of science during the century, he will learn the names of the great contributors to it and he will be informed of important sources of detailed information. But very few persons, if any, would find their interest sustained while reading the entire book.

F. R. M.

NATURE—IN ONE BOOK[1]

NATURE study is more than the study of nature. Beginning with simple, yet accurate observation, it organizes the knowledge so gained on a growing framework of understanding. At the same time, it encourages interest, liking and creative thought. In so doing, it links science with art and develops the individual's ability to enjoy the world. Nature study may begin with beetles or beans, but almost at once it tackles the task of improving human beings.

This view of nature study has been set forth by Bertha Stevens and a few other writers. Their books, however, only define attitudes and objectives. The actual methods of teaching or study, and the information to be gained, must be found in other volumes.

The foremost of these is Mrs. Comstock's *Handbook*. For 28 years, it has been a standard guide and reference, providing more—and more varied—information than is to be found in any other volume. From plants to mammals and from snowflakes to stars, it has given generations of users an understanding of, and enthusiasm for, things that count in the natural world.

Twenty-three printings, however, left the *Handbook* worn and out of date. These faults have been remedied in this new edition, which has been completely remade by a corps of specialists who still have kept Mrs. Comstock's flavor in writing. The specialists have brought the book up to the minute in information, have added extensive and very serviceable bibliographies, and have contributed hundreds of new illustrations. To accommodate these changes, the page size has been increased, the quality of paper improved, and the type reset in two columns. The result is a durable, attractive book whose price makes it a rare bargain.

More important, however, is the *Handbook's* all-round utility. Teachers and parents will find it a guide and sourcebook; interested adults may use it for identification; scientists will find it a guide to non-technical literature. In short, the *Handbook* is the most useful survey of nature in our northeastern states and eastern Canada now in print.

C. L. F.

[1] *Handbook of Nature Study*. By A. B. Comstock. Illustrated. xx + 937 pp. Revised Edition. $4.00. Comstock.

THE PROGRESS OF SCIENCE

DR. FRANK B. JEWETT, PRESIDENT OF THE NATIONAL ACADEMY OF SCIENCES

THE breadth of view of the leading scientists of the United States is illustrated in the unanimous election of Dr. Frank B. Jewett, an engineer, for a four-year term as president of the National Academy of Sciences at its recent annual meeting in Washington.

The Engineering Section of the academy, created in 1918, is the newest of the eleven sections covering the mathematical, physical and biological sciences. Dr. Jewett is the first engineer to be given a place in the distinguished roll of the academy's presidents, which includes such names as Alexander Dallas Bache, Joseph Henry, Wolcott Gibbs, Alexander Agassiz, Ira Remsen, William Henry Welch and other more recent ones.

The academy has always maintained the conception of the unity of science and has set store on the reciprocal illumination that one branch of science sheds upon another, on the theory that the scientific process is so fundamental to them all that the various branches have more in common than they have in their own separate fields.

In this catholic spirit, members of the Section of Astronomy participate equally with members of the Section of Anthropology and Psychology, and all the other sections, in the election of new members to the academy, irrespective of the fields from which the new members come.

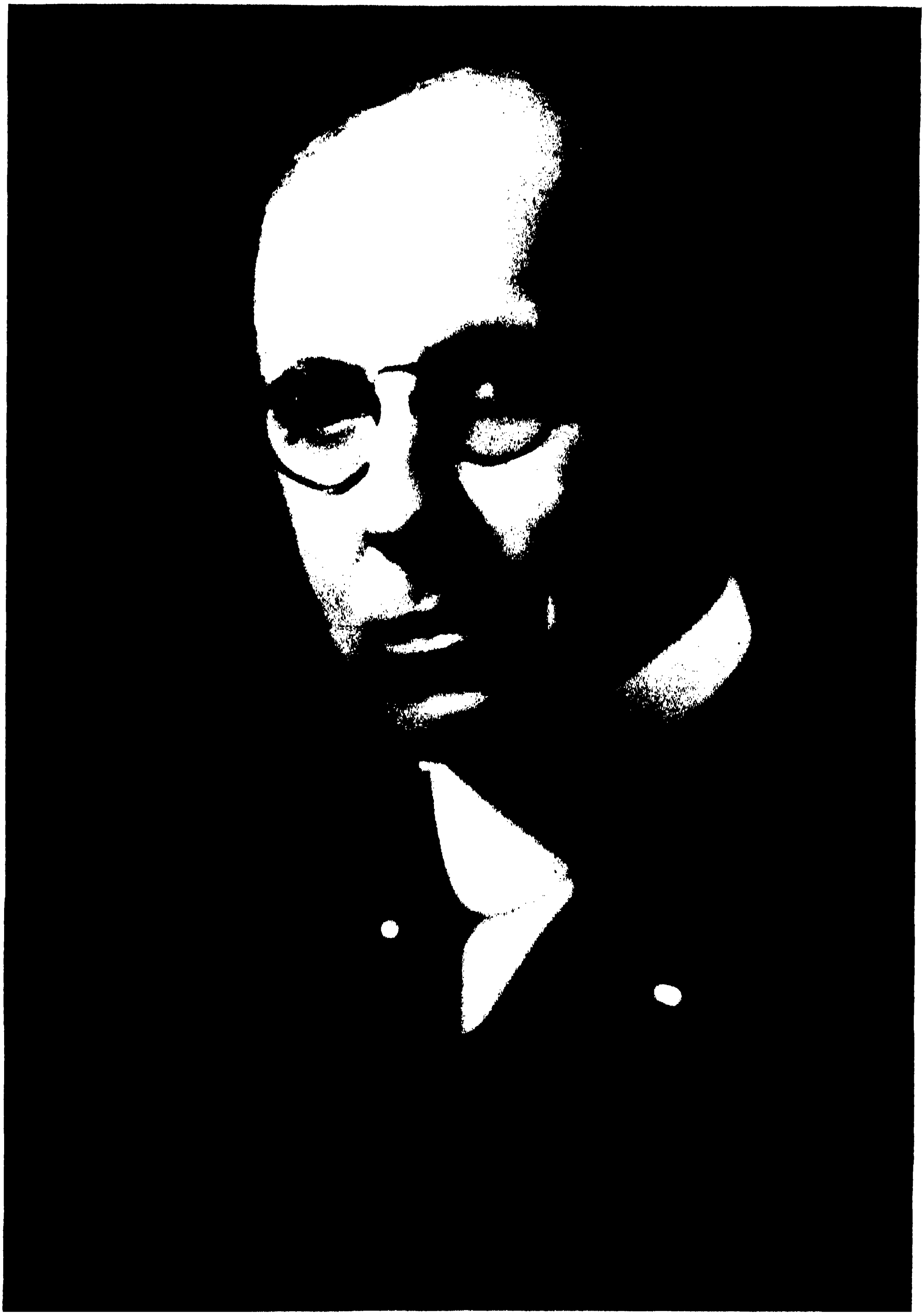
The election of an engineer for president is a recognition of the fact that science is the foundation also of engineering. This truth is illustrated by Dr. Jewett's career. As president of the Bell Telephone Laboratories and vice-president of the American Telephone and Telegraph Company in charge of research and development, he has been identified with the progress of pure science and in support of its promotion and of the development of research to an extent unequaled by any other engineer.

Besides his activities in the field of science, he has had the benefit of an unusual industrial experience, in having been chief engineer of the Western Electric Company, and later vice-president in charge of its large manufacturing operations.

Formerly chairman of the Division of Engineering and Industrial Research of the National Research Council, and familiar with that important agency of the National Academy of Sciences for bringing to bear in the national defense all the scientific and engineering resources of the country, he will be in a position to bring out the utmost usefulness of the academy itself to the government under the requirements of its charter, and to align the National Research Council and its engineering connections, in the event that the war services of the academy should again be called upon.

Dr. Jewett is a bachelor of arts graduate of Throop Polytechnic Institute, now the California Institute of Technology, and he took his Ph.D. in physics at the University of Chicago in 1902. He entered the telephone business in 1904, and to the solution of the great problems attending the growth of the telephone art he brought a rare mind trained to scientific procedure with which was coupled a gift as an organizer and administrator and a capacity for inspiring enthusiasm and friendships.

As a lieutenant colonel in the Signal Corps during the war, he directed the development of communication devices for both the Army and the Navy, and he was one of four members of a special advisory board on submarine detection.



Blackstone Studios

DR. FRANK B. JEWETT

He was also a member of the State Department Special Committee on Submarine Cables.

He has received many honorary degrees, among them doctor of science from New York University and Dartmouth College, in 1925; from Columbia University and the University of Wisconsin, in 1927; from Rutgers University, in 1928; from the University of Chicago, in 1929, and from Harvard University, in 1936. He received the honorary degree of doctor of engineering from Case School of Applied Science, in 1928, and the honorary degrees of doctor of laws from Miami University, in 1932, and from Rockford College, in 1939.

The Edison Medal of the American Institute of Electrical Engineers was awarded to him in 1928; in 1935, the Faraday Medal of the Institution of Electrical Engineers of Great Britain; in 1936, the Franklin Medal, and in 1938, the Washington Award of the Western Society of Engineers. His latest honor was the award of the John Fritz Medal, in 1939. He was also a member of the Science Advisory Board, to which he was appointed by President Roosevelt.

His scientific memberships are numerous. He is also a former president of the American Institute of Electrical Engineers, a trustee of the Carnegie Institution of Washington, the Woods Hole Oceanographic Laboratory and the Tabor Academy at Marion, Massachusetts.

Besides these connections, he is president and trustee of the New York Museum of Science and Industry, to which he has contributed a remarkable development, and he is a life member of the Massachusetts Institute of Technology Corporation.

The action of the academy in putting an engineer at its head will tend to amalgamate the forces of science and of engineering to an extent greater than ever before.

GANO DUNN

ANNUAL MEETING OF THE NATIONAL ACADEMY OF SCIENCES

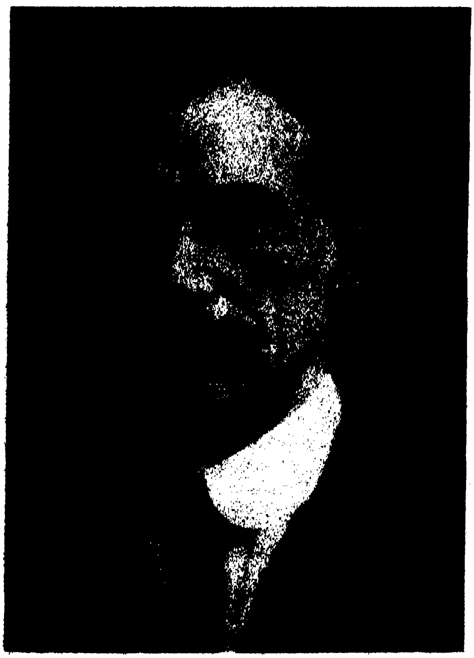
THE seventy-sixth annual meeting of the National Academy of Sciences was held on April 24, 25 and 26, at the Academy Building on Constitution Avenue, in Washington, D. C. One hundred and thirty-two members, including one member emeritus, were present; also four foreign associates. Many of the papers were necessarily somewhat technical in character; but, as a rule, they were presented in a form understandable to the scientific audience. Academy members realize that it is less easy to read a paper before the academy than before a technical society whose members are familiar with the details of the special field of research and with its technical expressions; they seek, therefore, to emphasize only the major results of their investigations and to state their significance in language easily understood.

Forty-five papers were presented. Their distribution among the different sciences was: mathematics, 3; astrophysics, 2; physics, 12; engineering, 1; geology, 2; meteorology, 1; biophysics, 8; biochemistry, 3; botany, 2; physiology, 5; pathology, 1; psychology, 1; history, 1; biographical memoirs, 3. Thirty-three papers were given by members, two by foreign associates, and ten by non-members. Two of the papers were read by special invitation. The great preponderance of papers on problems in physics, astrophysics, biophysics and biochemistry is an indication of the intense activity in these branches of science.

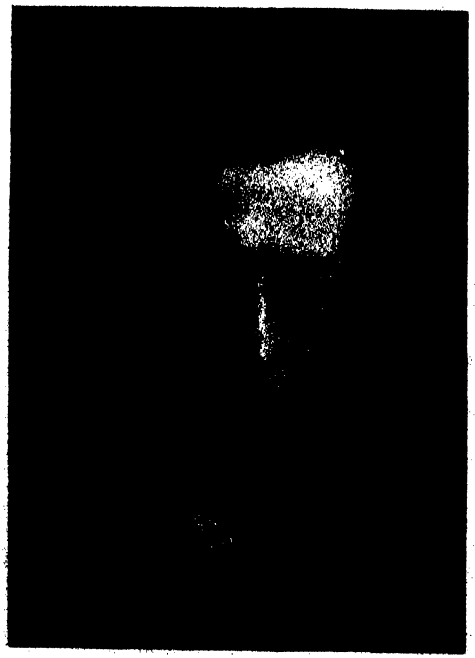
Drs. I. S. Bowen and A. B. Wyse presented the results of measurements of three spectra of the brightest planetary nebulae. They found more than 50 new spectral lines, of which they identified nearly one half. Computations based on the intensities of the spectral lines from

DR. GREGORY BREIT
PROFESSOR OF PHYSICS, UNIVERSITY OF WISCONSIN.

DR. GEORGE B. KISTIAKOWSKY
PROFESSOR OF PHYSICAL CHEMISTRY, HARVARD UNIVERSITY.



DR. F. G. COTTRELL
CONSULTING CHEMIST, RESEARCH CORPORATION, NEW YORK.



DR. A. BAIRD HASTINGS
HAMILTON KUHN PROFESSOR OF BIOCHEMISTRY, HARVARD UNIVERSITY.

DR. VLADIMIR N. IPATIEFF
RESEARCH DIRECTOR, UNIVERSAL OIL PRODUCTS COMPANY.

DR. W. J. MEAD
PROFESSOR OF GEOLOGY, MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

one of the nebulae showed that its chemical composition is similar to that of our sun.

Drs. A. H. Compton, M. Schein and P. S. Gill deduced from cosmic-ray data obtained in the northern and southern hemispheres of the Pacific Ocean a relation between cosmic-ray intensity and the thermal expansion of the atmosphere. Their data of observation show that the temperature coefficient of cosmic rays is less in equatorial regions than elsewhere, in accord with Blackett's predictions, based on Yukawa's hypothesis that mesotrons are produced in the upper atmosphere by less penetrating radiation, and show spontaneous disintegration similar to radioactivity. The calculations indicate that at latitude 38° the production of mesotrons is a maximum at about 42 kilometers altitude, corresponding to the abrupt change in the latitude effect; the seasonal variation in cosmic-ray intensity accords closely with the variations in latitude at which mesotrons are produced and confirm Blackett's predictions.

Drs. R. A. Millikan and V. H. Neher reported likewise upon seasonal changes in cosmic-ray intensities and found in higher latitudes the same increase of 2 to 4 per cent. in winter, but no appreciable change in the equatorial belt. Their measurements at very high elevations showed, however, much greater percentage changes and seem not to be in agreement with Blackett's hypothesis.

Dr. R. W. Wood described a new spectrograph method, based on the use of a special grating and special prisms, for ascertaining the radial velocities of stars.

Dr. Homer Dudley reported upon the results of work on the automatic synthesis of speech by electrical methods and illustrated the procedure and results by suitable phonograph records. The artificial speech was intelligible and reproduced well the inflection and timbre of the original.

In an invited paper on the active uptake of ions by organisms, Dr. August

Krogh described series of observations on fresh-water animals in which specialized mechanisms take up certain ions from the outside solution and concentrate them 100-fold in the blood. Separate mechanisms were found for kations and for anions. The suggestion was made that all these mechanisms are closely related; but thus far the nature of the process is not understood.

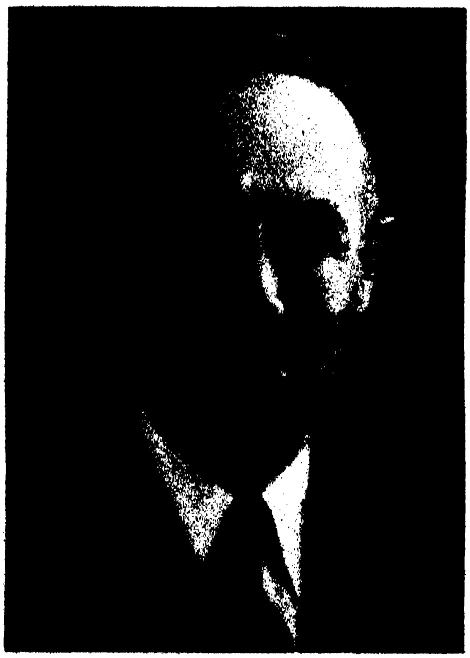
Dr. Douglas Johnson proposed a hypothesis of submarine canyon origin in which the chasms are ascribed to the action of water from submarine springs emerging along the seaward face of the continental shelf. These springs are fed by waters moving under artesian pressure through the sedimentary strata of the shelf and along planes of weakness.

Drs. C. E. Seashore and E. P. Horne described experiments on the function of the mute on the violin. They found that the weight of the mute is the chief factor in reducing the total intensity of the tone not in the fundamental, but in the partials at various levels. The change of harmonic structure varies with the string, the pitch level, the character of the violin and the mute itself.

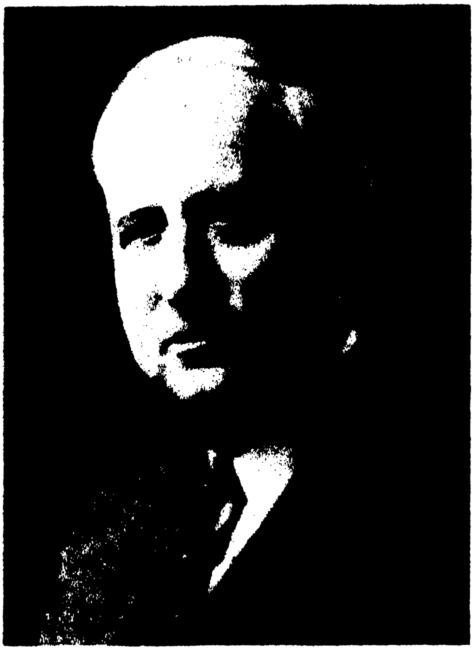
Drs. D. A. MacInnes and L. G. Longsworth reported upon electrophoretic studies on blood sera with the aid of a modification of the Tiselius apparatus in which changes in refractive index in the electrophoretic boundaries are automatically recorded. These records indicate the number, the mobilities, the amounts and the relative homogeneities of the proteins present. Pathological sera disclose abnormalities and departures from normal sera; the method promises to be useful in diagnosis.

On Monday evening the first Pilgrim Lecture to be given in this country was delivered by Sir William Bragg, president of the Royal Society and director of the Royal Institution. The lecture was the first one delivered in America under the six-year cooperative agreement between the Royal Society and the Na-

DR. ZAY JEFFRIES
TECHNICAL DIRECTOR, INCANDESCENT LAMP DEPARTMENT, GENERAL ELECTRIC COMPANY.



DR. DETLEV W. BRONK
JOHNSON PROFESSOR OF BIOPHYSICS, UNIVERSITY OF PENNSYLVANIA.



OSCAR RIDDLE
INVESTIGATOR, STATION FOR EXPERIMENTAL EVOLUTION, CARNEGIE INSTITUTION.

DR. D. F. JONES
GENETICIST, CONNECTICUT AGRICULTURAL EXPERIMENT STATION.

tional Academy of Sciences, providing that a lecture shall be given each second year before the Royal Society by an American scientist selected by the Royal Society, and each alternate year before the National Academy of Sciences by a British scientist selected by the academy. Funds in support of the lectureship were contributed by the Pilgrim Trust of Great Britain, a foundation established by Edward S. Harkness, of New York. The first Pilgrim Trust Lecture was given by Dr. Irving Langmuir in December, 1938, before the Royal Society. Sir William Bragg, on invitation by the National Academy of Sciences, delivered the second lecture of the series and chose for his subject "History in the Archives of the Royal Society."

In his address, Sir William traced the gradual change and growth of science since the incorporation of the Royal Society in 1662. The Royal Society has received and carefully preserved a very large number of papers and documents on scientific and other subjects, which reflect the development of science during the centuries and illustrate the changing attitude of society toward science. In the early years of the Royal Society the experimental science of its founders was simple and interested the entire membership; as knowledge increased, specialization became necessary and with it the adoption of technical terms and expressions in different fields, with the result that at present a scientist can encompass only a limited portion of scientific knowledge. The relation between science and human society has gradually become less immediate, but at the same time more important. Serious efforts are being made to lower this barrier of specialization by interpretation of the results of research in science to non-specialists. Sir William illustrated the progress of growth of science through excerpts from the society's archives and emphasized the responsibility that rests upon scientists not only to advance knowledge by

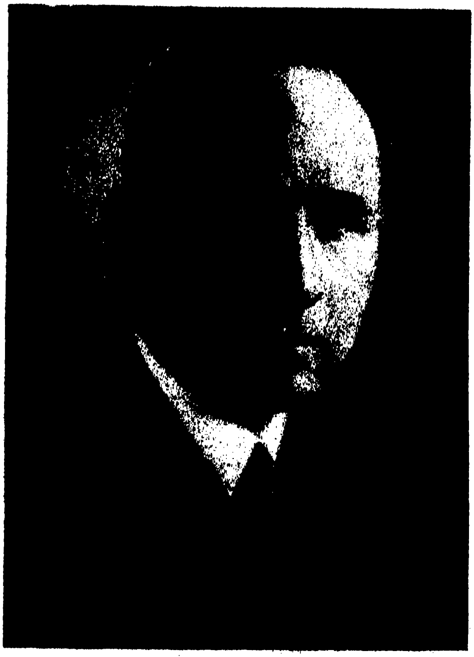
experiment but, by clear exposition, to acquaint others with these advances and with the scientific approach to problems as they arise, thereby greatly enhancing the human value of their efforts.

On Tuesday afternoon seventy academy members and guests visited the Supreme Court of the United States and listened to the presentation of a case before the court. After its adjournment, Justice Harlan F. Stone welcomed the group in a brief address and described the several features of special interest in the new building. The party was then shown over the marble structure and admired its architectural beauty, its winding staircases and its library facilities. The visit was extremely interesting and was much appreciated by the members.

At the annual dinner of the academy, on Tuesday evening, President Lillie reported upon the activities of the academy during the past year. In his address he referred to the functions of the academy in its relation to the government and to certain problems on which the government has requested advice; also to the work of the National Research Council. To quote from his address:

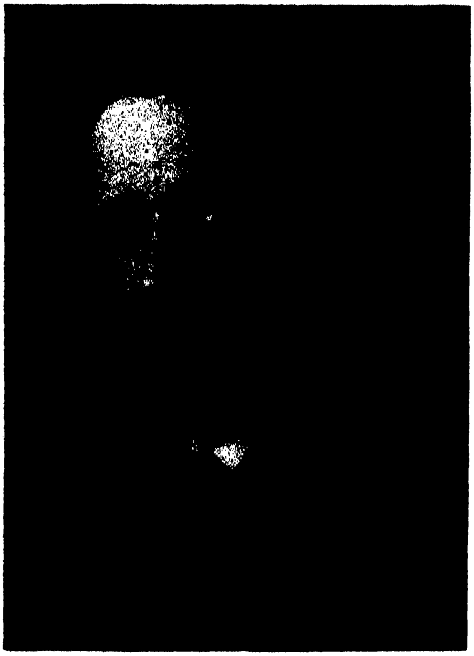
The Academy has adhered very consistently since its incorporation to the principle that the primary consideration for membership is convincing evidence, by scholarly character and productiveness, of devotion to the fundamental principles of science and the scientific way to knowledge, which are the sources of the discoveries and inventions that have transformed the social and economic conditions of modern life. There is no danger that we should depart from these principles. But it should be widely known that we fully recognize the social, economic, and national responsibilities that rest upon us, and that we are making every effort to discharge these responsibilities. The Academy occupies a very special position of responsibility in the relations between science and public affairs.

From the state of being largely ignored as a social and economic factor, science has in my own lifetime reached the condition of credit for complete transformation of the social and economic conditions of modern life, and this arouses expectations of new discoveries that will quicken old and create new industries, that will protect



DR. M. H. JACOBS
PROFESSOR OF GENERAL PHYSIOLOGY, UNIVERSITY OF PENNSYLVANIA.

DR. FREDERICK P. GAY
PROFESSOR OF BACTERIOLOGY, COLLEGE OF PHYSICIANS AND SURGEONS, COLUMBIA UNIVERSITY.



DR. ADOLPH H. SCHULTZ
ASSOCIATE PROFESSOR OF ANTHROPOLOGY, SCHOOL OF MEDICINE, JOHNS HOPKINS UNIVERSITY.

DR. W. B. CASTLE
ASSOCIATE PROFESSOR OF MEDICINE, HARVARD MEDICAL SCHOOL.

us in time of war, that will improve the health of the people and its innate qualities, and that will enable governments better to discharge their almost infinitely complex responsibilities.

It is unthinkable that the National Academy of Sciences should not respond to the utmost of its capacities. Created as it was to advise the agencies of the Federal government on any subject of "science or art," and pledged as each member is to render his services to the government without any compensation whatever, the present grave time calls for a renewed dedication to the service of our country. Our government expects and is entitled to this service from us by the very Articles of Incorporation.

DR. PHILIP E. SMITH
PROFESSOR OF ANATOMY, COLLEGE OF PHYSICIANS AND SURGEONS, COLUMBIA UNIVERSITY

The intention of the creators of the Academy was not, however, to establish another bureau under government control—either in the minds of the government or of the founders themselves—it was, on the contrary, to establish a free and independent body, with complete control over election to membership, that could be relied upon to advise without bias or fear. For this reason the no-compensation clause, to which I have alluded, was introduced; and for this reason the Academy has neither sought nor received financial support from the government.

At the conclusion of his address Presi-

dent Lillie awarded, on behalf of the academy, four medals:

The Agassiz Medal for Oceanography to Harald Ulrik Sverdrup, of the University of California; the Daniel Giraud Elliot Medal for 1933 and accompanying honorarium of $200 to Richard Swann Lull, of the Peabody Museum of Natural History, Yale University; the Daniel Giraud Elliot Medal for 1934 and accompanying honorarium of $200 to Theophilus Shickel Painter, of the University of Texas; the John J. Carty Medal and award for the advancement of science, consisting of a gold medal, bronze replica, certificate and $3,000 in cash, to Sir William Bragg, of the Royal Institution, London.

At the business session of the academy, Dr. Frank B. Jewett, president of the Bell Telephone Laboratories and vice-president of the Bell Telephone Company, was elected president of the academy for a term of four years, beginning July 1, 1939, to succeed Dr. Frank R. Lillie, emeritus professor of zoology at the University of Chicago. Dr. F. E. Wright, of the Geophysical Laboratory, Carnegie Institution of Washington, was reelected home secretary for a term of four years. Dr. Charles August Kraus, professor of chemistry at Brown University, and Dr. Alfred Newton Richards, professor of pharmacology at the University of Pennsylvania, were elected members of the council to succeed Dr. Simon Flexner, director emeritus of the Rockefeller Institute for Medical Research, and Dr. J. B. Whitehead, director of the school of engineering of the Johns Hopkins University.

Fifteen men were elected to membership in the academy:

Gregory Breit, University of Wisconsin.
Detlev W. Bronk, University of Pennsylvania.
W. B. Castle, Harvard Medical School.
F. G. Cottrell, Research Corporation.
Frederick P. Gay, College of Physicians and Surgeons, Columbia University.
A. Baird Hastings, Harvard University.
Vladimir N. Ipatieff, Universal Oil Products Company.
M. H. Jacobs, University of Pennsylvania.
Zay Jeffries, General Electric Company, Cleveland, Ohio.
D. F. Jones, Connecticut Agricultural Experiment Station.
George B. Kistiakowsky, Harvard University.
W. J. Mead, Massachusetts Institute of Technology.
Oscar Riddle, Station for Experimental Evolution, Carnegie Institution of Washington.
Adolph H. Schultz, School of Medicine, Johns Hopkins University.
Philip E. Smith, College of Physicians and Surgeons, Columbia University.

Three foreign associates were elected:

Sir Joseph Barcroft, professor of physiology, the University of Cambridge, England.
Sir William Bragg, director, the Royal Institution of Great Britain, and director, the Davy-Faraday Research Laboratory, London, England.
Dr. F. A. Vening Meinesz, professor of geodesy and cartography, the University of Utrecht.

The present membership of the academy is 304, with a membership limit of 350; there are six members emeriti. The number of foreign associates is 42, with a limit of 50.

The autumn meeting of the academy will be held this year on October 23, 24 and 25 at Brown University, Providence, R. I.

F. E. WRIGHT,
Home Secretary

MILWAUKEE A MECCA FOR SCIENTISTS IN JUNE

AT the beginning of the third week of June Milwaukee will be a mecca for eminent men from nearly all the major fields of science, for from June 19 to 24, inclusive, the American Association for the Advancement of Science will hold, in the Wisconsin metropolis, its one hundred fourth meeting.

Unlike the Mohammedans, scientists have many places at which they assemble for their communions—at Denver in June, 1937, at Indianapolis in the following December, last June in Ottawa, last December in Richmond, and now in Milwaukee. To scientists it is not a place, but Truth, that is sacred. To

them inspiration does not come down from authority but from the ardent fires in their own minds. They are not attempting to perpetuate fixed doctrines but eagerly and enthusiastically to explore new regions. They do not impose their ideas by the use of force but only by appealing to experience and reason. They do not dream of some distant Paradise but are happy now in working to produce one here on the earth.

The American Association for the Advancement of Science is the greatest integrating force in science in this country, perhaps in the world. In its own organization it has 15 sections, which together cover practically all of science. In addition, 169 scientific societies and organizations are affiliated with the association. There are corrective influences at work when scientists from different fields meet together. Horizons are broadened. Perhaps a more pertinent figure of speech is that when different scientists mingle there are cross fertilizations of ideas that are no less creative than are cross fertilizations in biology.

One of the important features of meetings of the association is comprehensive symposia on subjects which often run freely across the boundaries that circumscribe the various sciences and sometimes hinder their growth. For example, geologists, geographers and engineers will devote Friday, June 23, to soil conservation. The zoologists and the botanists, on June 20, will hold a joint symposium on "The Relation of Genetics to Geographical Distribution and Speciation."

Perhaps the symposia of greatest interest to the general public are the two that will be presented by the section on the social and economic sciences. One of these symposia, consisting of eight sessions, is on population and planning activities in the Northern Lake States. The other, consisting of five sessions, is on "The Economic System in Relation to Scientific Progress." The first of the ten papers in this program is on "The Capitalistic System and How It Evolved"; the topic of the last session, at which two papers will be presented, is "Government and Science." In these disturbed days these are interesting questions. The general public will be admitted to these sessions, as well as to all others at Milwaukee, and the principal addresses delivered will be followed by discussions from the floor.

It is an interesting commentary on science that scientists on the whole are not seriously apprehensive of the future. With the long ascent of man throughout the geological ages in the background of their consciousness, they have confidence in the vitality and adaptability of human beings and that they will survive the storms that threaten.

At each summer meeting the association provides an address by a distinguished scientist on some subject of general interest. This year the Maiben lecture, as it is known after the founder of the lectureship, will be delivered by Dr. Victor G. Heiser, author of "An American Doctor's Odyssey."

All the sessions of the Milwaukee meeting will be held from Monday, June 19, to Saturday, June 24. The meteorologists will meet on Monday and Tuesday; the chemists on Monday to Wednesday (Tuesday and Wednesday at Madison); the geologists and geographers, including their field trips, the entire week; the zoologists, on Tuesday, Wednesday and Thursday; the botanists on Tuesday; the ecologists, Tuesday to Thursday; the anthropologists, Tuesday to Thursday; the social scientists and economists, from Monday to Friday; the engineers, on Friday; the medical men, on Monday to Thursday; the foresters, including field trips, Monday to Sunday; the educationists, on Friday.

F. R. MOULTON,
Permanent Secretary

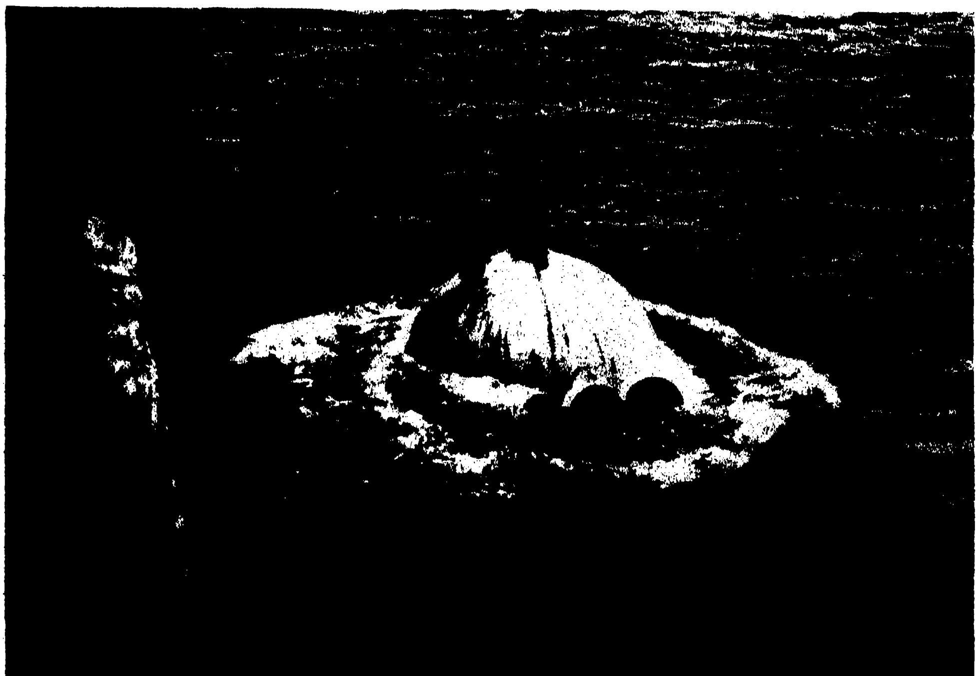
BIOLOGY AT THE NEW YORK WORLD'S FAIR

THE New York World's Fair offers for the student and teacher of biology a living laboratory rich in materials and unique in presentation. There are several buildings completely devoted to the biological sciences—notably the Hall of Man, the Medicine and Public Health Building, the food exhibit and the building of the New York Zoological Society. But the entire fair illustrates the pervasive role of science in general and biology in particular. In scores of the industrial buildings there are exhibits of special interest to the biologist. With the exception of the New York Zoological Society display, which charges a nominal fee, all the exhibits are free.

The Hall of Man, inscribed with the quotation from the Confessions of St. Augustine,

> Man wonders over the restless sea
> The flowing water
> The sight of the sky
> And forgets that of all wonders
> Man himself is the most wonderful,

is completely devoted to normal biology. The exhibit sponsored by the American Museum of Health and advised by a committee chaired by Dr. Livingston Farrand, was visited on the opening day alone by 59,348 people. There are displays of Spalteholz specimens, which were contributed by the Oberlaender Trust of Philadelphia. These actual human structures, rendered transparent by an oil immersion process, are ingeniously arranged in their relative positions in eight large cabinets upon which is painted the figure of a human body. There are also transparent specimens of the different animal phyla. The entire process of mitosis is graphically demonstrated by means of large glass models of cells in which both the chromosomes and spindle fibers can be seen. Beautiful models and transparencies of blood



—*"Half Mile Down," Harcourt, Brace & Co.*

THE BATHYSPHERE

IN WHICH DR. WILLIAM BEEBE DESCENDED ONE-HALF MILE INTO THE OCEAN. IT IS BEING DISPLAYED AT THE FAIR IN THE BUILDING OF THE NEW YORK ZOOLOGICAL SOCIETY.

THE GROWTH OF A TOMATO PLANT
DEMONSTRATED BY DR. J. W. SHIVE OF THE NEW JERSEY AGRICULTURAL EXPERIMENT STATION IN THE HEINZ LABORATORY AT THE FAIR.

cells as well as a striking presentation of blood groups according to the Snyder classification can be found in the Hall of Man. A large model of a brain studded with push buttons attached to figures of various functions which light up dynamically illustrates brain localization. Upon entering the hall a twenty-foot figure of a man is heard, as well as seen, since there is an amplified recording of the heart beat. One exhibit, which visitors wait in long lines to see, consists of models of a fetus in utero and the process of delivery. There are huge models of a tongue and the taste buds, the ear, the eye, and a table by which the visitor can demonstrate for himself various smell sensations by combining the three fundamental odors. Because of the many visitor-participation items, this is not the usual museum but a new type of laboratory which, judging from the interest of the participants, is proving a remarkably effective method of teaching.

The Hall of Medical Science consists of more than thirty-five large exhibits sponsored by various laboratories and scientific associations. One of the outstanding demonstrations is of the Carrel-Lindbergh perfusion apparatus, personally checked by Dr. Alexis Carrel at the fair on Friday, May 5. The dog's thyroid now in the perfusion chamber is expected to outlast the fair.

The story of allergy is simply but clearly told—the causative agents, the types of allergies, hay fever, asthma and eczemas, the water or oil soluble fractions of pollen which cause allergies and the hereditary tendencies are all demonstrated by colored transparencies.

An extremely interesting participation display is that sponsored by the American Medical Association. By a series of buttons and levers operated by the visitor he is briefly shown the subject-matter of nineteen of the medical sciences which are taught in the medical schools. Moving lighted currents illustrate the interdependence of the various hormones and the effect upon specific organs in the endocrine exhibit. A representation of the oestral cycle, goiter distribution maps, and a furnace with a damper opened, closed and at normal, illustrating the influence of the thyroid on metabolic rate, are all high spots of the endocrine exhibit.

The Health and Safety of the Worker Committee has prepared an exhibit showing a few of the occupational diseases and the health hazards in the production of many of the articles in daily use.

An important social consequence of the fair can already be envisaged in many of the displays in this hall. Here simply and clearly the layman is able to obtain accurate information of the latest scientific discoveries. For example, the recent work of Dr. Stanley on viruses, the new membrane method of virus culture, the work on testosterone—the male sex hormone—are all presented. Sulfapyridin, accepted by the American Medical Association in the week of May 5, is described in the section on pneumonia, al-

though used experimentally for over a year. Thus the approval of a therapeutic agent through the fair reaches the physician and the layman at the same time.

The New York Zoological Society's building illustrates some of the activities of its three major departments—the Zoo, the Aquarium and the Department of Tropical Research. The actual Bathysphere in which Dr. William Beebe descended into the ocean off the coast of Bermuda is in the Bathysphere-shaped building, the walls of which contain many deep sea forms which fluoresce under an ultra-violet light. In a relatively small space the visitor gains a tremendously broad scope—life from the depths of the sea to the mountain tops of Tibet, as exemplified by the giant panda, from the saber-toothed tiger and the mastodon to man, from the brilliantly colored tropical fish and birds, "the Crown jewels," to the leaf-cutting ants, a diorama of the sinking of the Hudson Gorge, an Austral-Asian habitat group—all these are designed to persuade the normal man of the breadth and dynamics of biology.

In the Food Building constructed by the fair there is a section dedicated to the illustration of the formula, "Man equals chemicals equals Food." Vitamins and the deficiency diseases are portrayed. The New York City Building is peppered with biological material. As the visitor rounds a corner he views the monkeys and birds in the small zoo. In the exhibit of the New York Botanic Gardens a large model of Krubi, the eight-foot flower of Sumatra, opens and closes. The American Museum of Natural History display, backed by a replica of a section of the Planetarium, consists of several miniatures of the habitat groups, the originals of which are to be found in the halls of the museum. A huge chameleon atop a pedestal, bearing a large transparency of a cross section of the skin and explaining the action of the chromatophores in producing color changes, is found in the foreground.

PROTOZOA PROJECTED ON THE SCREEN
A DRAWING OF ONE OF THE EXHIBITS SHOWING DR. GEORGE ROEMMERT SILHOUETTED AGAINST ONE OF TWELVE SCREENS IN THE MICROVIVARIUM.

Behind the ideas of the singing tower, the time capsule and Moto—the mechanical man—there is a vast amount of biological material in the Westinghouse Electric Building. A microvivarium, directed by Dr. Georg Roemmert, consists of a semi-circular darkened gallery containing twelve screens five feet in diameter. Here protozoa, hydra and rotifers magnified 2,000 times are seen swimming about. A demonstration of the Sterilamp—a new type of ultra-violet lamp—and its bactericidal properties is also demonstrated in this microvivarium. General Motors also has a microvivarium in which one sees molds and mixed protozoa culture.

Of extreme interest to the teacher of biology is the hall devoted by the Westinghouse Company to the American Institute's science and engineering clubs. Here are dioramas of plant propagation, the evidences of evolution models of protozoa in which the same color is used for

the contractile vacuole in several forms, another color for the nucleus, etc., and here is a laboratory where students are working on hydroponics, demonstrations of which are also seen in the Heinz exhibit and Gardens on Parade.

A lethal chamber, testing the killing time of various solutions on house flies, a termite colony, a group of Mexican bean beetles happily feeding on sprayed and control plants, are all features of a display in the du Pont company building.

A large glass-enclosed working dairy laboratory, in which technicians are performing all the routine tests of milk examination, is found in the exhibit of the Sealtest Company.

For the specialist, the Department of Science and Education conducts an information service. Here will be classified, according to scientific subject, all the items of scientific interest. There is an auditorium in this building in which scientific and medical motion pictures are shown and which is available for meetings of scientific organizations.

GERALD WENDT,
Director of Science and Education

BOK PHOTOGRAPHIC MUSEUM OF THE FRANKLIN INSTITUTE

THE new Cary W. Bok Photographic Museum of the Franklin Institute was opened early this year, the centennial of Daguerre's announcement of the first successful photographic process. The purpose of the section is threefold: to tell the history of photography; to explain the basic principles of apparatus and the various processes of producing photographs; and to show examples of fine photography, both pictorial and scientific.

The visitor enters the section through a gallery arranged to show approximately one hundred photographs. Here, the effective and novel system of illumination immediately strikes him. The prints are illuminated from above by concealed lighting, using the new General Electric daylight fluorescent tubes, mounted in special reflectors which direct the light down along the wall, without allowing it to spread back more than about two feet into the room. Thus no direct light strikes the visitor (there is no other light in the gallery) and reflections on the glass are reduced to a minimum.

—*Gladys Müller*
A VIEW ACROSS THE EXHIBIT HALL SHOWING SAMPLES OF EARLY PHOTOGRAPHY

Each month the prints on display are changed. One-man shows by outstanding photographers and collections from various societies and clubs are being exhibited. Steps are being taken to build up a fine permanent collection.

Two doors lead from this gallery into the remainder of the photographic museum, the first into a small studio designed to illustrate principles of correct portrait lighting. Here the visitor can take pictures of his own model with his own camera under ideal conditions. A camera stand is provided, and, at present, three different lighting arrangements, controlled by interlocking switches, are available. Framed examples of portraits made in the studio are mounted near the switches. Only the lowest priced reflectors are used, to encourage the visitor to attempt similar work at home.

The second door' from the gallery leads to the balcony around the second floor Graphic Arts section, a hall 88 feet long and 24 feet wide, which forms the main exhibition space for the section. On entering the door, the visitor faces a blank wall in the center of which is a two-foot square ground glass. On this screen appears an inverted image of the opposite end of the room, formed by a lens of three-foot focal length built into a large camera on the other side of the wall. Turning to the left, he finds various exhibits explaining the formation of images, and the development of the camera obscura before the invention of photography.

—*Gladys Müller*

THE AMATEUR PHOTOGRAPHIC STUDIO

WHERE THE VISITOR CAN TAKE PICTURES USING HIS OWN MODEL AND CAMERA. THERE ARE THREE DIFFERENT LIGHTING ARRANGEMENTS WITH WHICH HE CAN EXPERIMENT.

The simplicity of photography is demonstrated by an exhibit comparing photographs made using a camera constructed at a cost of nineteen cents with pictures of the same subjects using elaborate and expensive equipment. The portraits and landscapes displayed show clearly that fine pictures of some subjects can be made with very simple equipment.

Exhibits consisting of thirteen units operated by push-buttons are used to show the optical properties and defects of simple lenses. Actual images are formed by lenses on ground-glass screens, and the objects projected are chosen to bring out the points being explained. The various defects of lenses, such as spherical aberration, coma, etc., are presented. Another exhibit of six units explains the meaning of F numbers and five units are used to show how depth of focus depends on the aperture and the focal length of the lens used. The same principles are used in showing the development of the camera obscura and the action of a lens in forming an image.

Another group of exhibits is concerned with exposure. Here a large collection of exposure meters is shown, and an exhibit dealing with the determination of correct exposure is under construction. The results of correct and incorrect exposure, as well as various examples and causes of good and bad prints, are shown by means of a series of negatives and prints from them.

On exhibit at the present time is a portion of a very fine collection of historical items, including the oldest camera in America. It is intended to further emphasize the history of photography, especially the very important part played by Philadelphia in the development of the art.

Also, the institute has on display an unusual collection of early motion picture apparatus. In the future exhibits will be added to explain motion pictures.

WAGNER SCHLESINGER

AERONAUTICAL RESEARCH AND DEVELOPMENT

INTERNATIONAL developments of the past year, and the steps now under way to augment the size and effectiveness of our aerial defences, make particularly appropriate a consideration of what this country is doing from the scientific point of view to improve the quality of the equipment used by its flying services.

Size alone of an aerial military force is a minor factor in determining its efficiency as compared with that of possible opponents. Coupled with airplanes and accessories of the highest order must be an operating force adequately trained to handle them, together with repair facilities and the myriad of items which are necessary to "keep the planes in the air."

It has been truthfully said that the airplane of the present day does not differ fundamentally from its predecessor of 1914. There has, however, been a steady improvement in performance. While a speed of 60 miles per hour was considered satisfactory in the earlier days, no plane of the fighting or pursuit type is considered for future development with a speed not in excess of 400 miles per hour, while engineers are already talking of a 500 miles per hour ship. These results, which have been steadily achieved from year to year, have been obtained primarily through engineering research. Apparently minor details, such as the setting of rivet heads flush with the skin of the ship, have added miles per hour to speed.

This engineering research may be divided into three separate classes, which may, however, in certain cases show a small amount of overlapping. First, is what is generally known as fundamental research. This is carried on in the United States in the laboratories of the National Advisory Committee for Aeronautics, located at Langley Field, Virginia. The results of these investigations are then considered by the Army experimental plant at Wright Field, and applied to military aircraft, both of the Army and the Navy.

The third class of research is that carried on by civilian institutions, such as some of the leading technical schools, which possess the necessary equipment. This is used by the aeronautical industry located in close proximity, for the purpose of solving problems in connection with the design of specific airplanes, although a certain amount of the work is sometimes performed by the manufacturing plants themselves.

Research is not confined to airplanes alone, but to such related things as engines, fuels and instruments. And it must not be forgotten that research which is at first directed primarily toward the development of military airplanes and accessories is bound to be reflected also in the improvement of civil aircraft.

While a few years ago the United States led the world in the quality of its aircraft, this leadership since then has been diminishing. A number of the European nations have greatly augmented their research facilities. For example, as compared with our single basic laboratory at Langley Field, Germany now possesses no less than five, one of which alone employs a personnel several times the size of that of the N.A.C.A.

We have been taking steps to improve our position. We are greatly expanding the Army plant at Wright Field, and hope to spend more than $6,000,000 in aeronautical research and development alone.

While we have lost ground within the last few years we have not been idle, but, even though limited in funds, have been remarkably successful in many experimental projects. The United States possesses engineering skill and brains equal to those anywhere in the world. With the additional facilities which are being asked for, there seems to be no reason why we should not be able to regain the ground which has been lost, and once more lead the world in aeronautical development.

HENRY H. ARNOLD,
Chief of the U. S. Army Air Corps

INDEX

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